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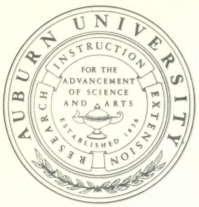

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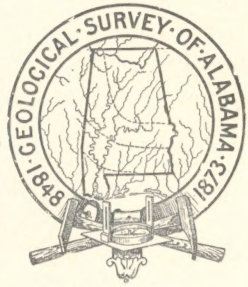
GEOLOGICAL SURVEY OF ALABAMA
WALTER B. JONES, State Geologist

BULLETIN 62

GROUND-WATER RESOURCES OF THE HUNTSVILLE AREA, ALABAMA

By
P. E. LaMOREAUX, G. W. SWINDEL, JR.,
and
C. R. LANPHERE

Prepared by the
UNITED STATES GEOLOGICAL SURVEY
In Cooperation with the
GEOLOGICAL SURVEY OF ALABAMA



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LETTER OF TRANSMITTAL

University, Alabama
May 24, 1950

Honorable James E. Folsom
Governor of Alabama
Montgomery, Alabama

Sir:

I have the honor to transmit herewith the manuscript of a report entitled "Ground-Water Resources of the Huntsville Area, Alabama" by P. E. LaMoreaux, G. W. Swindel, Jr., and C. R. Lanphere, of the United States Geological Survey. It is requested that it be printed as Bulletin 62 of the Geological Survey of Alabama.

Respectfully,

WALTER B. JONES,

State Geologist.

151044

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GROUND-WATER RESOURCES OF THE HUNTSVILLE AREA, ALABAMA

By

P. E. LaMOREAUX, G. W. SWINDEL, Jr., AND C. R. LANPHERE

ABSTRACT

Huntsville and vicinity in north-central Alabama lies partly in the Cumberland Plateau section of the Appalachian Plateau but mainly in the Highland Rim section of the interior low plateau.

The rocks that crop out in the area of this report range in age from Silurian to Pennsylvanian, although the surface formations consist for the most part of Mississippian limestones overlain by outliers of Pennsylvanian sandstone, shale, and coal. The structure in the area is relatively simple, the rocks dipping gently to the southeast.

The large water supplies for industrial and municipal use in the area come mainly from solution cavities and other openings in the massive limestone of Mississippian age, particularly the Tuscumbia limestone and the Fort Payne chert. Below the Mississippian limestones, water in the Chattanooga shale and underlying rocks is highly mineralized.

Only a part of the ground-water supplies is developed in the area, and additional supplies could be obtained from the full development of springs in the area, and properly located wells.

INTRODUCTION

Purpose of Investigation

This report is the second[1] in a series of reports designed to present information on the ground-water supplies in particular municipal and industrial areas of the State of Alabama. These areas have been chosen because of the large ground-water installations already in use for both municipal and industrial purposes, and because planned future expansion in these areas will

[1]Peterson, Carl G. B., Ground-water investigations in the Mobile area, Ala.: Alabama Geol. Survey Bull. 58, 1947.

necessarily lead to the supplemental development of ground water for existing and new water-supply systems. Investigations of the water resources are a part of the State-wide cooperative ground-water program of the Alabama Geological Survey and the Ground Water Branch, United States Geological Survey.

Work was begun in the Huntsville area early in 1945 as a result of severe water shortages during two periods of low flow of Huntsville Spring in the late summer and fall of 1943 and 1944. At the request of the City a weekly water-level recorder was reinstalled at Huntsville Spring on March 25, 1945.

The report will serve a twofold purpose in giving a record and interpretation of the hydrologic conditions of Huntsville Spring as well as pertinent data with regard to the occurrence, availability, quality, and quantity of ground water in the Huntsville area. No attempt was made to determine the bacteriological content of ground water in the area.

Acknowledgments

The investigation was under the general supervision of A. N. Sayre, geologist in charge of the Ground Water Branch, U. S. Geological Survey, in cooperation with Dr. Walter B. Jones, state geologist of the Alabama Geological Survey. Immediate supervision of the investigation and the writing of this report was given by V. T. Stringfield, Senior Geologist of the Ground Water Branch.

During the field work much valuable assistance was given by officials, many citizens, and representatives of industry in Huntsville and vicinity. Through the cooperation of N. M. Payne, city clerk of Huntsville, and James S. Wall and the Huntsville Water Committee, the services of T. H. Good were made available for the operation of the continuous water-level recorder at Huntsville Spring. The information furnished by these persons led to a more complete understanding of the ground-water conditions in the area. In addition, acknowledgment is made to Messrs. Carl and Edwin Jones and members of the firm of G. W. Jones and Sons, who made available certain basic data, including the base map of the city, and who cooperated in every way to make this report possible. Acknowledgment is given also to Miss Winnie McGlamery, paleontologist of the State Geological

Survey, for information on oil-test well logs, and to Tom DeJarnette, staff photographer, Alabama Geological Survey, and John B. Hendricks for photographic work for the report. Through the full cooperation of E. B. Rice, C. H. Hardison, M. R. Williams, and members of the U. S. Geological Survey, Surface Water Branch, Montgomery, Ala., check measurements on Huntsville Spring were made to correlate with the mechanical water-level recording equipment. In addition, discharge measurements were made by M. R. Williams on four large springs in the Huntsville area during 1949.

Previous Investigations

One of the earliest geologic reports containing information on the area of the present report is the interpretation of the geology of northern Alabama by Michael Tuomey in his second biennial report (1858, pp. 6, 16-18, 42).[2] Included with this report is a generalized geologic map, which shows the area to be underlain by limestone with outliers of sandstone capping the higher hills.

In 1896 a special report on the valley regions of Alabama, by Henry McCalley, the assistant state geologist, was published.[3] Included in that report were the first detailed descriptions of the geography and geology with some reference to the occurrence of ground water for the valley area. The latest and most comprehensive geologic report that contains information on the area is the section on Paleozoic rocks, by Charles Butts, geologist, U. S. Geological Survey, included in Special Report 14 of the Alabama Geological Survey.[4]

One of the earliest scientific references to Huntsville Spring is found in Tuomey's second biennial report (1858). Since then various measurements have been made and published. A list of references and temperature records for Huntsville Spring, which are believed to be complete and in chronological order, may be

[2]See list of references, pp. 10-11.

[3]McCalley, Henry, Report on the valley regions of Alabama (Paleozoic strata), Part 1, The Tennessee Valley region: Alabama Geol. Survey Spec. Rept. 8, 1896.

[4]Adams, G. I., Butts, Charles, Stephenson, L. W., and Cooke, C. W., Geology of Alabama: Alabama Geol. Survey Special Rept. 14, pp. 162-183, 1926.

found in the present report in the section on the development of the Huntsville municipal supply (p. 44).

The first detailed investigation of the hydrology and geology of Huntsville Spring was made from November 1928 to March 1930. During that investigation an automatic water-stage recorder was placed on the spring, and spring flow was correlated with rainfall. Data obtained then were published in 1933 in Alabama Geological Survey Special Report 16, "Ground water in the Paleozoic rocks of northern Alabama", by W. D. Johnston, Jr. Included in the same publication is a discussion of the general occurrence, quality, quantity, and availability of ground-water supplies in Madison County and in all of northern Alabama. Also included, in part 2 of the report, are data from 12 wells and 8 springs. These wells and springs were revisited and more recent data obtained for this present report.

The following bibliography lists most of the reports that contain information on the geology and ground water of Huntsville and vicinity. Specific references to them are cited in the appropriate places in the text.

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Field Work

During the early part of the investigation for this report C. W. Carlston made arrangements for the installation of a water-level recorder at Huntsville Spring. At this time a partial well inventory was made for the area. Just prior to the installation of the recorder, the Ground Water Branch requested the Alabama office of the Surface Water Branch, at that time under the direction of E. B. Rice, to investigate conditions at Huntsville Spring and to install staff gages and make discharge measurements of the spring. Using these discharge measurements, a rating chart was compiled for determining flow of the spring over the lower weir. During this study the normal capacity of the pumps at the Huntsville Waterworks was determined. Since this early investigation by the Alabama office of the Surface Water Branch, additional check measurements have been made at Huntsville and other large springs in the area by members of that office.

During the period March 23, 1945, to June 1948 periodic trips to the area were made by the senior author to investigate several proposed industrial ground-water supplies. Completion of the well and spring inventory was made by C. R. Lanphere, G. W. Swindel, Jr., and P. E. LaMoreaux from June to November 1948. Field work was essentially completed in December 1948 and January 1949 with a study of drainage wells in use in the area.

GEOGRAPHY

Location, Topography, and Drainage

Huntsville, the county seat of Madison County, lies in the north-central part of the area of this report, which includes approximately a six-township area in the south-central part of Madison County. Included are Tps. 3, 4, and 5 S., and Rs. 2 and 1 W and 1 E. Huntsville lies 10 miles north of the Tennessee River and 19 miles south of the Tennessee State border. The area of the report is approximately 100 miles north of Birmingham, Ala.. and 107 miles southwest of Chattanooga, Tennessee.

This area in south-central Madison County lies partly in the Cumberland Plateau section of the Appalachian Plateau and

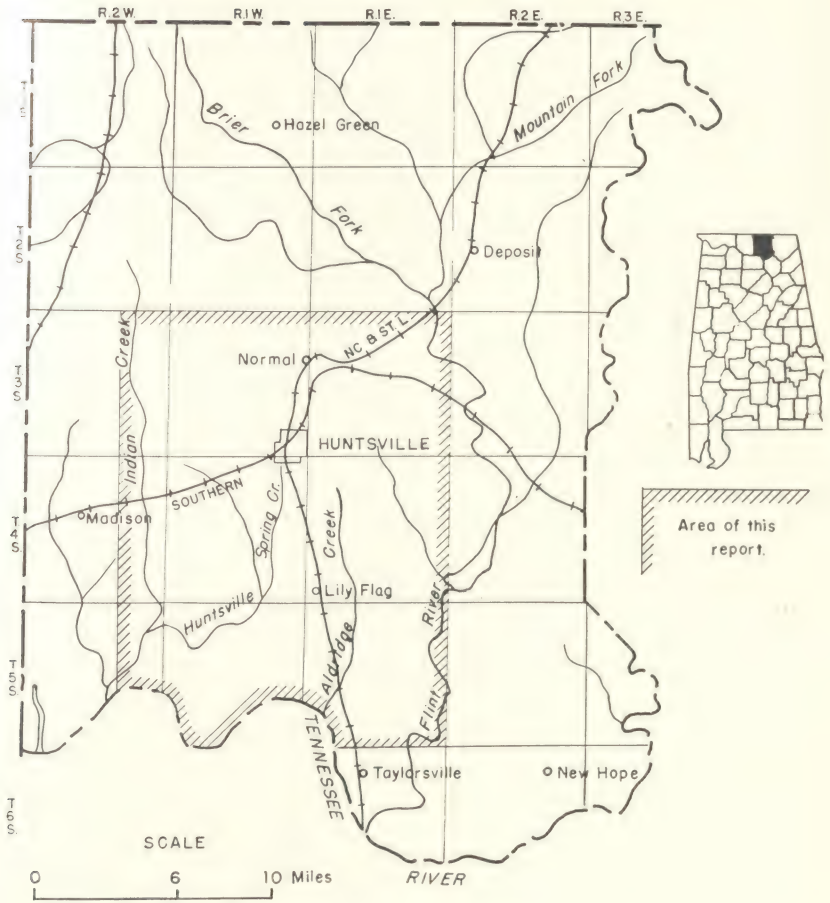

Figure 1. Index map of Madison County, Ala., showing the Huntsville area.

partly in the Highland Rim section of the interior low plateaus. The dividing line between these provinces roughly follows the line of the Nashville, Chattanooga, and St. Louis Railway (see index map) south of Huntsville along the western slope of Monte Sano to the Tennessee River, although several outliers of the Cumberland Plateau capped by beds of the Pottsville formation lie east of the boundary line. Dissection of the old plateau is so well advanced that the tablelike summits, remnants of the old Cumberland Upland capped by the Pottsville formation, occupy but a small part of the area of the county. Monte Sano, east of Huntsville, is probably the best known of these remnants. It extends 16 miles from north to south as a narrow plateau, its small tablelike upland surfaces being separated by saddles along the ridge. West of the N. C. & St. L. Railway is the interior low plateau known in Alabama as the valley of the Tennessee River.

The predominant topography throughout the area of the report is broad rolling hills ranging in altitude from 600 to 800 feet above sea level. There are a few conical hills, outliers of the Appalachian Plateau.

From Huntsville southward to the Tennessee River the low-lying area is underlain by Mississippian limestones, which are essentially horizontal. These limestones have weathered in most places to a rich reddish-brown residual soil covering the bedrock to a depth of 20 to 40 feet or more. As a result of this deep-soil development, outcrops of limestone are relatively few. Bedrock is seen at only a few localities such as Huntsville, Byrd, and Brahan Springs and in the area adjacent to Monte Sano and the conical hills. The excellent soil has aided the development of a rich agricultural region where cotton, corn, hay, tobacco, and timber are the principal crops. Also of agricultural importance to the area are feed grains, winter cover crops, and nursery stock.

Drainage in the area is entirely southward to the Tennessee River. Streams draining the area from west to east include Indian Creek, Huntsville Spring Creek, Aldridge Creek, and the Flint River.

Climate

South-central Madison County has a mild climate with a mean annual temperature of about 61° F., a mean winter temperature of 43° F., and a mean summer temperature of 80° F. The annual rainfall averages 47 inches. The growing season is about 200 days, the climate being favorable to the growth of many varieties of crops. After the winter rains the somewhat dry spring and early summer weather is ideal for cotton and other crops needing warmth and little rainfall. The summer rains fall during July and August when moisture is needed for the growing crops. The period of low rainfall occurs during September, October, and sometimes November, at harvest time.

A graphic summary of the climate of Huntsville and vicinity is presented in figure 2. The climatic data at Madison, 9 miles west of Huntsville were used to prepare this graph because of the much longer period of observation there. In the upper part of the chart three curves represent the average maximum, average monthly, and average minimum monthly temperatures over a 47-year period. Below the graphs a straight line represents the average length of the growing season. The length of this line is determined by the earliest and latest dates in the year on which a temperature below 30° F., was recorded. The bar graph at the bottom of the figure indicates the highest, lowest, and mean precipitation for each month, based on data from 1894 to 1948.[5]

The average annual temperature for the climatic observation station at Madison for a 55-year period was 60.6° F. For the Huntsville station the average annual temperature for a 10-year period was 59.7° F. The lowest average temperature at Madison during 1948 was for January, 34.2° F., which was 8.0° F. below normal. The highest average temperature was for July, 79.4° F., which was 0.4° F. below normal. The highest temperature at Madison during 1948 was 100° F., recorded on July 5; the lowest, 5° F., was recorded on January 18.

Most of the samples of ground water collected from springs and shallow wells 20 to 40 feet deep in the area of this report approximated the mean annual temperature of 60.6° F. The

[5]Climatological data: U. S. Weather Bureau, Montgomery, Ala., 1949.

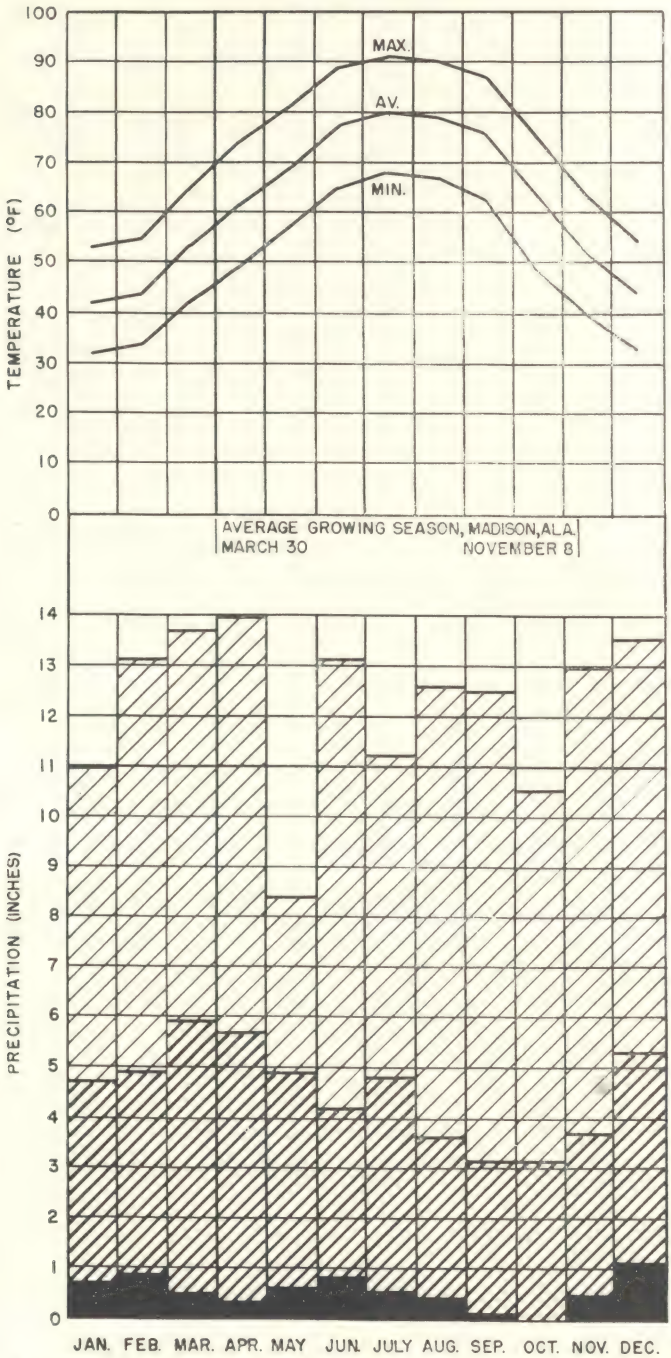

Figure 2. Climatological chart for 47-year period at Madison, Ala., showing minimum, average, and maximum temperatures and precipitation averaged monthly over this period.

temperature of water samples from the deeper wells of the area ranged from 60° to 64° F.

Development and Population

Huntsville and vicinity became a cultural, trade, and agricultural center early in the history of the State. The city, originally named Twickenham, was chartered in 1805, only 6 years after John Hunt, its first settler, located at Huntsville Spring and began clearing away the wilderness for his small farm. Early settlement in the area was rapid, owing to the large spring, the unusual fertility of the soil, and the beauty of the surrounding country. Because of the rapid early development and building Huntsville became the first incorporated town in northern Alabama. It had the first cotton gin in the State, in 1809; the first newspaper, in 1812; the first governmental land office, in 1817; it was the site of the first State Convention, in 1819; and when Alabama became a state of the Union, it was the State's first capital. Huntsville also had the first public library, first bank, and the first municipal waterworks in the State, installed in 1823.[6]

In 1850 Huntsville had a population of 2,863. By 1940 it had increased to 13,050, and in 1948 the normal increase plus the increase caused by the extension of the city limits made up an estimated population of 22,000.[7]

Transportation and Industry

The city of Huntsville is connected north and south by U. S. Highway 241 (Florida Short Route) and east and west by U. S. Highway 72 (Lee Highway). State and county highways serve the surrounding country and outlying communities. Paved State highways include Alabama 1, 20, 38, and 97. Three bus lines connect Huntsville with Gadsden, Anniston, Birmingham, Nashville, Florence, Sheffield, and Chattanooga. An east-west trunk line of the Southern Railway and a north-south line of the Nashville, Chattanooga, and St. Louis Railway furnish railroad accommodations for the area. Three air lines make char-

[6]Betts, E. C., Early history of Huntsville, Ala., 1804 to 1870, Brown Printing Co., Montgomery, Ala., 1916.

[7]Letter from L. H. Pinkston, Secretary, Huntsville Chamber of Commerce, Feb. 7, 1949.

tered stops at Huntsville Airport. The Tennessee River, 10 miles south of Huntsville, provides a 9-foot navigation channel and water transportation to inland ports on the Mississippi, Missouri, Ohio, and Tennessee Rivers.

Principal industries include cotton mills, cotton oil, heaters and stoves, shoes, farm implements, chemical products, concrete products, rubber products, and nursery stock. Industrial growth in the area has been rapid, owing to an excellent water supply, transportation facilities, surrounding market area, suitable climate, and other economic factors.

GEOLOGY

The geology of the Huntsville area is outlined in the early generalized geologic map prepared by Michael Tuomey (1858). Subsequently, Henry McCalley studied the geology and geography of the Tennessee Valley region, and his report (1896) includes information on Madison County. The latest Geologic map, showing the accepted nomenclature, distribution, and description of the formations in the area, was compiled by Charles Butts and published in Special Report 14 of the Alabama Geological Survey (1926). The geologic information supplied in the tables and text of the present report was obtained mainly from that publication, and was supplemented by a study of the rocks in the Monte Sano road-cut exposures.

The rocks that crop out in Madison County range in age from Silurian to Pennsylvanian, although the surface formations of the area of this report consist for the most part of Mississippian limestones overlain by outliers of Pennsylvanian sandstone, shale, and coal of the Pottsville formation. These beds are essentially horizontal, dipping gently to the south and east.

Important in the understanding of the ground-water conditions in the area is the following sequence of rocks: the Chattanooga shale of the Carboniferous or Devonian system crops out in a small area on the Flint River, and is penetrated by some of the water wells of the area. As shown in these well logs, the Chattanooga shale is underlain by a light-gray limestone of the Silurian system, probably of the Niagara group. Overlying the Chattanooga shale is about 100 feet of gray hard, and in places

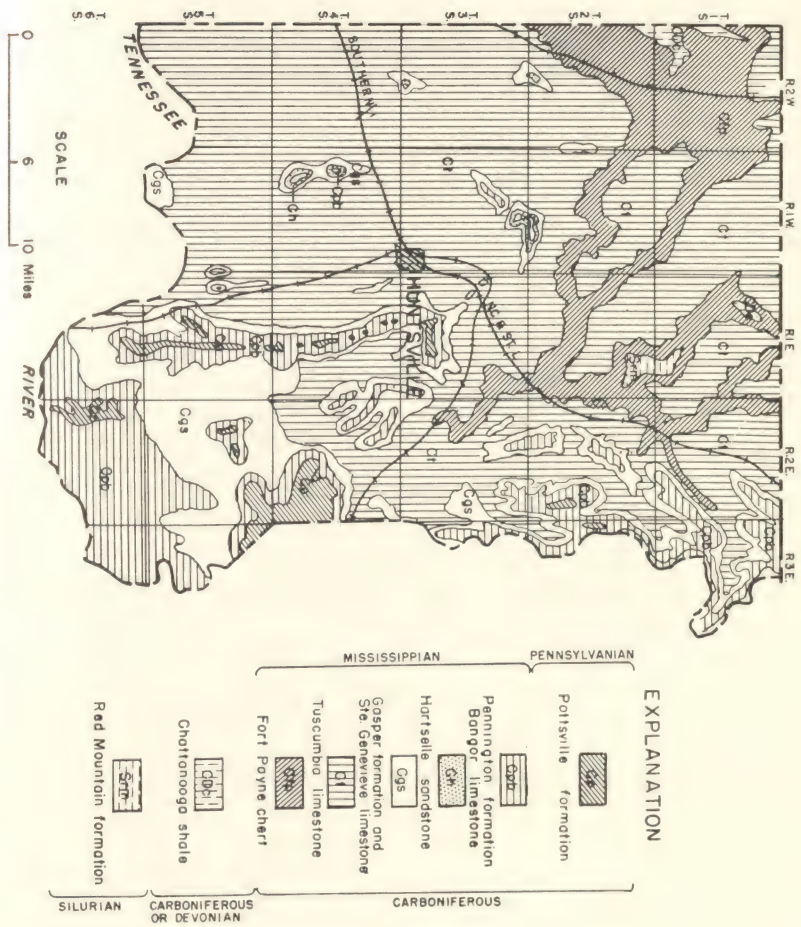

Figure 3.—Geologic map of Madison County (enlarged and modified from geologic map of Alabama, 1926)

cherty, limestone, the Fort Payne chert of the Mississippian series. The Tuscumbia limestone overlies the Fort Payne chert and was deposited over the entire area of what is now the Cumberland Plateau and Highland Rim physiographic divisions in northern Alabama. It is divided into two limestone units of Warsaw and St. Louis age. These units are lithologically similar and can be distinguished only on the basis of the fossils they contain. Both of these limestone units are mapped together as the Tuscumbia limestone on the geologic map of Alabama (1926). This procedure is followed in this report also. Overlying the Tuscumbia limestone are the Ste. Genevieve limestone, Gasper formation, Hartselle sandstone, Bangor limestone, and the Pennington formation of the Mississippian series. The Pennington, in turn, is overlain by the Pottsville formation of the Pennsylvanian series.

The exposures in road cuts along U. S. Highway 241 from Huntsville to the entrance of Monte Sano State Park and from there along the Park road to the WHBS radio tower on the crest of Monte Sano were described and measured in order to show the geologic section and thickness of formations in the area. These exposures were supplemented by a water-well log at Dr. Whitaker's clinic, just east of the intersection of Alabama Highway 38 and U. S. Highway 241. This composite section measured by A. F. Agnew and P. E. LaMoreaux of the U. S. Geological Survey on May 28, 1949, is as follows:

Section in road cuts along U. S. Highway 241 and the Monte Sano State Park road to the base of the WHBS radio tower from junction of U. S. Highway 241 and Alabama Highway 38 (Altitudes in feet above sea level, were determined by aneroid barometer).

	Feet
Carboniferous system:	
Pennsylvanian series:	
Pottsville formation:	
Sandstone, tan-gray to buff, predominantly medium-grained, but coarse to conglomeratic in basal 20 feet (Millstone grit), cross-bedded, thin- to heavy-bedded	60+
Coal (Cliff seam)	2
Shale, gray, with many sandstone ledges in lower half of bed, with **Calamites**	18

	Feet
Mississippian series:	
Pennington formation (altitude at top, 1,489 feet)	
Shale, red-tan to brown, sandy, tough	12
Limestone, gray, crystalline, coarse-grained, cross-bedded, with crinoid fragments, echinoid spines, **Pentremites** and other fossils; medium-bedded	15
Shale with limestone ledges. Shale, purple, green, and gray, plastic; interbedded with earthy limestone, greenish-yellow to yellow; weathers to gray-cream color. Medium- to thin-bedded, breaks with conchoidal fracture	51
Bangor limestone (altitude at top, 1,411 feet):	
Shale and limestone. Shale, calcareous, greenish-gray, thin-bedded, and interbedded with ledges of argillaceous limestone, light-gray to white, dense, dolomitic, in places nodular and with vugs containing travertine	40
Limestone, blue-gray, thick-bedded, very fossiliferous, coarsely crystalline, oolitic and with **Pentremites**, corals, brachiopods, and crinoid stems	65
Limestone, gray, dolomitic, dense, hard; breaks with conchoidal fracture	15
Limestone, light-gray, fine-grained, hard, and with chert lenses; breaks with conchoidal fracture	55
Road to Monte Sano State Park.	
Limestone, as above, with some scattered cherty matter. At base a 3-foot zone of weathered shale or thin-bedded calcareous limestone	80
Limestone, gray to light-gray, medium- to massive-bedded; fossiliferous	35
Limestone, gray to gray-tan, thin-bedded; weathers shaly	6
Limestone, blue-gray, medium- to thick-bedded, with some cherty matter, fine-grained, dense; breaks with conchoidal fracture; fossiliferous	50
Hartselle sandstone (altitude at top 1,065 feet):	
Sandstone, tan to brown, banded, medium- to coarse-grained, hard; large impressions of **Sigillaria** in upper 1 foot of bed	10

	Feet
Gasper formation (altitude at top 1,055 feet):	
Limestone, gray, fine- to coarse-grained, cross-bedded, fossiliferous, with many crinoid fragments and other fossils	95
Ste. Genevieve limestone (altitude at top 980 feet):	
Limestone, gray to tan-gray, fine-grained, moderately soft and medium- to thin-bedded	20
Limestone, blue-gray to light-gray, massive-bedded, fine- to medium-grained, in places oolitic, and with some chert	145
Tuscumbia limestone (includes limestones of St. Louis and Warsaw age) (altitude at top 800 feet):	
Limestone, blue-gray to gray, hard, dense, massive- to thin-bedded, cherty, with some lenses and layers of coarsely crystalline fossiliferous limestone	150+
Lower interval covered; limestone exposed in excavations near intersection U. S. Highway 241 and Alabama Highway 38 appears to be Tuscumbia.	
Intersection U. S. Highway 241 and Alabama Highway 38—at bottom of road section: altitude 645 feet. Section continued in well at Dr. Whitaker's clinic on southwest corner of intersection.	
Top Whitaker Clinic well (altitude 635 feet):	
Soil and clay with cherty lumps	20
Fort Payne chert (?):	
Weathered chert	16
Limestone, gray to light steel-gray, very hard	95
Carboniferous or	
Devonian system:	
Chattanooga shale:	
Shale, black, sulphurous	5
Silurian system:	
Niagara group (?):	
Limestone, light-gray, hard	9
Limestone, dark-gray, soft	20
Limestone, gray, hard	35

A correlative section for Monte Sano is diagrammed on page 60 of the Guide book, seventh field trip of the Mississippi Geological Society. A similar but much deeper subsurface section than shown in the Whitaker water well was compiled by Walter B. Jones from drill cuttings and log from the West Huntsville well 2 in SE¼ sec. 3, T. 4 S., R. 1 W. (Semmes, 1929).

The black Chattanooga shale recorded in the Whitaker well has been encountered by many water wells in the immediate vicinity of Huntsville, at depths of 130 to 175 feet. Below the black shale, ground water is highly charged with minerals and is objectionable for industrial and municipal use.

Structure

The structure of the formations in the area of this report in general appears to be relatively simple. The entire area lies west of the folded valley-and-ridge province in an area of nearly flat-lying beds of Mississippian limestone. No prominent faults or disturbed zones are known, although minor fractures or folds may be present in the area.

The most important structural features governing the occurrence of ground water in the area are the extensive joint and bedding-plane systems and crevices in the limestones. The exposures of these bedded limestones at Huntsville Spring, Brahan Spring, Byrd Spring and in the road cuts up Monte Sano show the extensive development of solution cavities.

The following table describes the thickness, lithology, and hydrologic properties of the formations in the area. Of primary importance as water bearers are the Fort Payne chert and the Tuscumbia and Bangor limestones. These limestone beds are extensively cut by solution channels, which allow the ready passage of ground water. Little consideration is given to the rocks underlying the Chattanooga shale, because of the great increase in mineral content of water below this formation.

Table 1. Geologic Formations Exposed at Huntsville and Vicinity

System	Series	Formation	Thickness (feet)	Character of material	Water-bearing properties
Quaternary	Recent	Alluvium	0-30	Unconsolidated silt, clay, and chert gravel deposited in the flood-plain areas of the Tennessee River and tributary streams.	Source of moderate supplies from dug wells. Water low in mineral content.
Carboniferous	Pennsylvanian	Pottsville sandstone	100+	Sandstone, brown and gray-brown, medium- to coarse-grained, massive and thin-bedded; some shale and a coal bed near the base of the formation.	Yields small quantities of ground water adequate only for domestic supplies. Water from openings along joint and bedding planes and fractures in the sandstone. Water generally high in iron.
	Mississippian	Pennington	80-100	Shale, red, gray, and green, sandy, with a few shaly limestone beds.	Relatively impervious. Yields little or no water to wells or springs in area.
		Bangor limestone	350	Limestone, blue-gray, massive, hard, and in part fossiliferous; contains some dolomitic limestone layers and shaly beds in upper part.	Yields moderate supplies of ground water where wells intersect solution channels. Some large springs issue from the formation in the Madison County area.
		Hartselle sandstone	5-10	Sandstone, tan to brownish-gray, medium- to coarse-grained, hard.	Yields little or no water to wells or springs.
		Gasper	90	Limestone, light-gray to gray, crystalline, abundantly fossiliferous, oolitic in part, and with some shaly zones.	Yields moderate quantities of water to wells and springs. Because of its geographic distribution in the hills and mountains of the area it is unimportant as a source of industrial and municipal supplies.
		Ste. Genevieve limestone	180	Oolitic limestone, light-gray, thick-bedded, fossiliferous. On weathering yields much chert.	Contains an extensive series of solution cavities which supply moderate quantities of water to wells and springs.
		Tuscumbia limestone	200	Crystalline limestone, dark to light-gray, massive, fossiliferous, with some cherty layers.	Yields abundant water from tubular openings. Source of supply for many springs and wells in the area.
		Fort Payne chert	100	Predominantly a cherty limestone, gray to yellow, porous; weathers to yellow angular blocks.	A good aquifer, yields water to many wells in area that penetrate solution channels in the formation.
Carboniferous or Devonian		Chattanooga shale	2-10	Shale, black, hard, fissile, bituminous.	Rock generally impervious and not water-bearing. Water from joint cracks generally high in hydrogen sulfide.
Silurian		Niagara group (?)	70	Limestone, light-gray, fine-grained, hard; some soft beds.	Source of moderate quantities of ground water. Solution cavities not extensively developed. Yields mineralized water with hydrogen sulfide odor.

Silurian system

Niagara group(?)—In well logs in the vicinity of Huntsville and south as far as Farley, drillers record a dove-colored or light-gray hard lime with soft streaks underlying the Chattanooga shale. These beds are assigned to the Niagara group (?) by the Alabama Geological Survey (Semmes, 1929).

This limestone, about 70 feet thick, apparently contains fractures and solution cavities, for wells at Dr. Whitaker's clinic, the Roper Floral Co., and a public school at Farley develop water from it. In every well the water has a sulphurous odor, and an analysis shows that water from the Roper well is highly mineralized.

Carboniferous or Devonian system

Chattanooga shale.—The Chattanooga shale was named by Hayes from exposures of black shale near Chattanooga, Tenn. It is distributed over all the northern part of Alabama northwest of the Coosa River, except where it has been removed by erosion. In Madison County it is exposed 2 miles northwest of Madison cross road on Limestone Creek and at Quick's Mill, 4 miles from New Market on Flint River. In this area it ranges from 2 to 10 feet in thickness, and consists mainly of a densely black highly fissile shale. The formation is a poor aquifer because of its thinness and lithology. Where water is obtained from these beds or below, it is high in hydrogen sulfide, has a strong odor, and objectionable amounts of iron, calcium, magnesium, sodium, sulfate, and chloride (Johnston, 1933, p. 115).

Carboniferous system—Mississippian series

Fort Payne chert.—The Fort Payne chert was named from the Fort Payne area, DeKalb County, and was originally defined by Smith in 1890. The original definition has been restricted somewhat and, at present, is applied to the basal very cherty formation of the Mississippian series in Alabama. The Fort Payne chert originally was deposited over nearly all the northern part of the State. It is exposed as either bedrock or float composed of solid chert having a porous stony texture, gray to yellow-gray and spotted by black manganese or iron stains. The rock has many fracture planes along which it

breaks down into finer material in the natural course of weathering. Included in the chert are lenses of dark green-gray to gray shale. The thickness of this formation in the area of this report is estimated to be 100 feet.

The Fort Payne chert is highly fossiliferous, and is characterized by many crinoid stem plates and the large spirifers, which are useful for the identification of the weathered product.

The Fort Payne chert is an excellent aquifer as it is cut by a great number of joints and fracture planes, forming interconnecting voids which serve as reservoirs for ground water. These openings, where filled with water, supply wells with sufficient water for domestic, industrial, and municipal use. Several large springs flow from this formation in the area adjacent to the Huntsville area. One of the largest of these is Meridianville Spring about 7 miles north of Huntsville. This spring was reported (Johnston, p. 271) to flow about 3 second-feet (1,346 g.p.m.) on July 12, 1929. Some of the deeper water wells in the area of this report take their supplies from the Fort Payne chert. Below lies the Chattanooga shale which yields water too highly mineralized for industrial use.

Tuscumbia limestone.—The limestone units of Warsaw and St. Louis age are herein considered as a unit, for which the name Tuscumbia limestone is applied. The limestones were mapped together and no differentiation was attempted between wells in the two formations.

The Tuscumbia limestone is exposed in road cuts on U. S. Highway 241 near the base of Monte Sano, in the 50-foot bluff at Huntsville Spring, and in the vicinity of the other large springs of the area. The thickness of the Tuscumbia limestone is about 200 feet.

Both of these limestone units which make up the Tuscumbia limestone consist of massive and thin beds of coarsely crystalline dark- to light-gray compact fossiliferous limestone, with some interbedded layers of gray chert. Much of the formation is composed of crinoidal plates and bryozoa. The limestone of St. Louis age overlies the limestone of Warsaw age and contains the characteristic St. Louis species of corals, *Lithostrotion canadense* and *L. proliferum*. In addition, it contains layers

of dark fine-grained limestone unlike limestones in the underlying unit of Warsaw age.

The Tuscumbia limestone is composed largely of calcium carbonate containing little magnesia or other relatively insoluble impurities. Consequently, the formation is subject to a great amount of solution by the percolation of slightly acid water along bedding and joint planes and fractures in the formation. These extensive solution channels allow the ready passage of ground water through the formation, and make the Tuscumbia limestone the best water-bearing formation in the area.

The elaborate system of solution channels supplies, where the water table intersects the land surface, many springs such as Huntsville Spring, Indian Spring, Brahan Spring, and Byrd Spring. Many industrial and municipal wells 50 to 150 feet or more in depth penetrate openings or solution cavities in the limestone carrying ground water. The amount of water yielded to these wells depends on the size of the openings in the limestone. Examples of the potential capacity of these solution channels are shown by the discharge of Huntsville Spring, the measured flow of which has been as much as 26 million gallons a day, and of Byrd and Brahan Springs each of which flows a million gallons a day or more. Eight wells having a diameter of 8-⅝ inches and depths of 107 to 110 feet were drilled at Lincoln Mills below the bottom of a dug well 20 feet in diameter and 60 feet deep. This well system supplies the mill and the community with more than a million gallons of water a day.

Ste. Genevieve limestone.—The Ste. Genevieve limestone was named for exposures near Ste. Genevieve, Mo., 40 miles south of St. Louis. Previous to the publication of Special Report 14, which describes the geology of Alabama, the Ste. Genevieve was not differentiated as a distinct stratigraphic unit. On some older geologic maps it was included either as part of the Bangor limestone or as part of the Tuscumbia limestone. The limestone identified as the Ste. Genevieve is present throughout the Tennessee Valley. Some of the best outcrops of the Ste. Genevieve in the vicinity of Huntsville are in the road cuts leading up to Monte Sano. The altitude of the base of the formation in this section is about 800 feet above mean sea level, and its top, about 975 feet. Another good exposure of 80 feet or more of Ste. Genevieve limestone may be seen at the conical hill 8 miles south of Huntsville, just northwest of Farley. The

limestone is also well exposed in the middle slopes of Rainbow, Smithers, and Capshaw Mountains where the underlying Tuscumbia limestone is well exposed. The thickness of the Ste. Genevieve is about 180 feet.

It is a thick-bedded gray oolitic limestone, consisting chiefly of small nodular bodies that have a concentric structure resembling a mass of fish eggs. Upon weathering it yields much gray chert. The main mass of oolitic limestone is separated by a few non-oolitic beds, generally lighter in color and weathering to almost white. The oolitic characteristic of the limestone differentiates it from the underlying Tuscumbia limestone. The formation contains a distinctive fossil crinoid, *Platycrinus huntsvillae.*

The Ste. Genevieve limestone is relatively soluble and contains an extensive series of solution cavities along bedding and joint planes. Although generally considered a good aquifer, it is of little importance as a source for industrial and municipal supplies because it crops out only on the slopes of the hills and on the side of Monte Sano. Most wells obtaining their water from this formation are shallow dug and drilled wells which yield an adequate supply for domestic and farm use.

Gasper formation.—The Gasper formation was named from exposures on the Gasper River, Warren County, Ky. It was originally called the Gasper oolite, but in Alabama the name Gasper oolite is applicable only in Jackson and Madison Counties, for elsewhere in the State the formation is mainly shale. In the area of this report the Gasper formation lies unconformably upon the Ste. Genevieve limestone. The oolitic limestone facies of the formation is well exposed on the west slopes of Monte Sano at Huntsville, where its upper contact is at an altitude of about 1055 feet above mean sea level. Exposures may be seen also in the conical hill 8 miles south of Huntsville and in the slopes of Rainbow, Capshaw, and Smithers Mountains north and west of Huntsville. The thickness of the Gasper is about 90 feet.

The Gasper formation consists of an oolitic thick-bedded light-gray to gray crinoidal limestone with a few beds of light-gray non-oolitic fine-grained limestone and some beds of shaly limestone. The formation is similar lithologically to the under-

lying Ste. Genevieve, although these formations can be readily separated by their fossils and the unconformity between them. The main guide fossils of the Gasper are the compound coral *Campophyllum gasperense* and species of the general *Talarocrinus* and *Pentremites*.

The Gasper limestone may be considered a moderately productive aquifer, but because of its geographic distribution high on the slopes of the conical hills and Monte Sano it has little significance as a water-bearing formation in the area of this report except as a source for domestic and farm wells. Most of the wells obtaining their water from the Gasper formation are dug or shallow drilled wells capable of furnishing as much as 25 gallons a minute.

Hartselle sandstone.—The name Hartselle sandstone was introduced for outcrops of this formation near Hartselle, Morgan County, Ala. The formation crops out extensively throughout northern Alabama. In the area of this report it caps Capshaw Mountain, the west outlier of Smithers Mountain, and is present in the road cuts at the north end of Monte Sano. It is present also in the conical hill 8 miles south of Huntsville.

In Madison County the formation consists of a bedded medium- to coarse-grained hard sandstone made up of well-cemented quartz grains. It is 5 to 10 feet thick in exposures at Monte Sano and in the conical hill 8 to 10 miles south of Huntsville. Because the sandstone is well cemented it is relatively unimportant as an aquifer.

Bangor limestone.—The name Bangor limestone was given to exposures of limestone near Bangor, Blount County, Ala. Good exposures of this limestone may be seen throughout Madison County except in the western part where it has been removed by erosion. It is well exposed along the road from Huntsville up Monte Sano, where it ranges from 350 to 400 feet thick. In the natural well of Monte Sano, described on page 53 of Special Report 16, the formation is exposed to a depth of 350 feet in a vertical solution channel in the Bangor limestone.

The Bangor limestone consists mainly of a hard limestone, blue-gray to gray, and thick-bedded; it includes beds of massive

oolitic crystalline limestone and some dolomitic limestone with shaly beds in the upper part. In part the limestone is very fossiliferous, bryozoa and brachiopods being the most abundant fossils. The Bangor contains some species that are either confined to this formation or are rare in other formations. They include *Prismopora serrulata, Pentremites pyramidatus* and *P. brevis,* the brachiopod *Spirifer increbescens* and *Composita subquadrata.*

Like the other soluble limestones in the area of this report the Bangor is a very productive aquifer. It is cut by many interconnecting solution cavities which furnish water to wells. In addition, the Bangor yields water to numerous springs in its area of outcrop. Because it crops out on the upper slopes of the conical hills and of Monte Sano, it is of little importance in the development of municipal or industrial supplies. However, it does furnish water to many springs and shallow dug wells for domestic and farm use.

New Hope Spring at the town of New Hope, about 5 miles southeast of the southeast corner of the area of this report, rises from a sink in the Bangor limestone. This spring was reported to yield 1,346 gallons a minute (Johnston, p. 273).

Pennington formation.—The Pennington formation was named by M. R. Campbell for red and green shales with sandstone ledges exposed at Pennington Gap, Lee County, Va. In the area of this report its lithology is identical to that at the type locality. This formation is not shown in the area of this report on the geologic map of Alabama (1926), however, good exposures of the formation may be seen in the road cuts on Monte Sano, where it is about 80 feet thick. The formation underlies the Pottsville formation and overlies the Bangor limestone.

The Pennington formation consists of unfossiliferous red, green, gray, and buff shales, in places sandy, and contains some layers of shaly limestone and sandstone.

No wells are developed in the Pennington formation in the area of this report, as the formation is predominantly shale, and therefore relatively impermeable. Where more permeable beds overlie it, the formation acts as a barrier to the downward per-

colation of water, and the upper surface or contact may be a spring line.

Pennsylvanian Series

Pottsville formation.—The name Pottsville formation was taken from the town of Pottsville, Pa., in the anthracite coal field. The basal part of this formation is exposed on Monte Sano, which is capped by an outlier of the formation. The Pottsville ranges in thickness from a few to as much as 200 feet in the area of this report. In the exposure near the top of Monte Sano it overlies the Pennington formation of the Mississippian series.

The formation is a series of beds of shale, sandstone, and coal. One of these coal beds, the Cliff seam, was formerly mined in the Monte Sano area. In exposures on the road to Monte Sano State Park, the formation consists of gray, tan, and brown, medium- to coarse-grained and in places conglomeratic, cross-bedded, medium- to heavy-bedded sandstone with some gray shale and a coal bed.

The outcrop of the Pottsville formation in the area of this report is confined to the crests or hilltops of its outlying remnants. Ground water occurs in the formation along bedding and joint planes and in fractures in the sandstone. It does not have the perviousness or porosity of the underlying Mississippian limestones. Yields from this formation are relatively small, from 5 to 25 gallons a minute. In the residential area on Monte Sano many drilled and dug wells in the formation supply adequate ground water for domestic and farm use.

Hydrology

Most of the Mississippian formations—the Fort Payne, Tuscumbia, Ste. Genevieve, Gasper and Bangor formations are excellent aquifers. Of these formations the Fort Payne chert and Tuscumbia limestone are important as sources of industrial and municipal water supplies, as they form the bedrock throughout the major part of the lowland area of the county. These limestones contain elaborate systems of solution channels which are conduits for large flows of ground water. Where the water table intersects the land surface, these channels supply springs

such as Huntsville, Brahan, Byrd, and Indian Springs. Where these cavities in the limestone lie above the water table they act as conduits for drainage of surface water to the water table. The normal fluctuation of the water table during the year may result in the alternate filling and complete draining of water from these cavities.

Many private, industrial and municipal wells in the Tennessee Valley area penetrate openings or solution cavities in the limestone carrying ground water. These openings are difficult to locate from the surface and are generally found by test drilling. Fortunately, the solution cavity systems are so extensive that few wells extending to a depth of 100 or 150 feet fail to penetrate one or more cavities.

Illustrative of the extensiveness and potential capacity of solution channels through these limestone beds in the Huntsville area are the above-mentioned springs, of which Huntsville Spring flows approximately 3 million gallons to as much as 26 million gallons of water a day. Byrd, Indian, and Brahan Springs each flow a million gallons a day or more. At Lincoln Mills, eight 8-⅝-inch wells 107 to 111 feet deep have been drilled below the bottom of a dug well 20 feet in diameter and 60 feet deep. A stationary 750-gallon-a-minute turbine pump mounted at the top of the well operates continuously for 24 hours, supplying the mill and the community with more than a million gallons of water a day. However, by using auxiliary pumps mounted on a pontoon in the well, this system has furnished more than 2 million gallons a day with no appreciable drawdown.

In calcareous rocks such as the Mississippian limestones in the area of this report the largest openings are secondary, having been formed after the limestones were deposited. Joints, faults, and other fractures and openings along the bedding planes permit the descent and lateral movement of water. This water derived from precipitation on the land surface and percolation through the soil is charged with carbon dioxide and organic acids derived from decaying vegetation. The acid solution attacks the limestone, as calcium carbonate is readily soluble in weak acid and gradually dissolve it away, enlarging the openings and increasing the porosity and permeability of the rocks.

Solution of calcareous rocks is believed to be most effective near the water table where water containing carbon dioxide descends along the joints and other fractures. Both vertical and lateral solution are common along joint and bedding planes. With the increased size of the solution cavities and increased flow, abrasion by water carrying sediment becomes effective, tending toward the further enlargement of the openings of the subterranean drainage system. The drainage pattern developed is similar or comparable to a surface drainage system. The underground streams, like surface streams, adjust themselves to a base level, which in the area of this report is either the water level in the Tennessee River or large tributary streams. This system discharges into these streams, tending in time to become graded to base level. In an advanced stage of development of a subterranean drainage system the controlling laws are essentially the laws of flow of surface streams.

It may be seen, therefore, that the storage or discharge capacity of a limestone is directly dependent upon the development of solution cavities. Formations similar to the Tuscumbia limestone and Fort Payne chert are well jointed and extensively cut by solution cavities to form excellent ground-water reservoirs with large capacities. These reservoirs are recharged continuously by precipitation on the land surface percolating through the soil zones and into the openings of the rock and to the water table. So long as the volume of water pumped from a well does not exceed the quantity of water that is recharged by rainfall, a well or spring will yield a permanent supply. If the quantity of water pumped from a well or water-bearing bed exceeds the quantity recharged, the deficiency must be supplied from storage if storage water is available. Excessive withdrawals can continue only until the water in storage is greatly diminished or is depleted.

Large industrial and municipal water-supply developments in the Huntsville area are of two types: those using spring water, such as Huntsville city supply, Merrimack Mills, and the water cress farms using water from Indian and Acuff Springs; and those using wells, such as are in use at Lincoln and Dallas Mills.

The satisfactory development of a spring supply is entirely dependent on the normal flow of the spring, its fluctuation, the

quality of its water, and its location. Accessibility of water from a spring may be aided by the removal of loose debris from the discharge point or channel opening, construction of an intake basin, installation of pumping equipment, and necessary clearing, screening, or covering around the opening of the spring to keep it as free of pollution as possible.

The development of a well supply in the same area, however, is more problematical as it is dependent upon the water-bearing capacity of the openings intersected by the well. The location or depth of these openings, as a rule, cannot be determined from a surface examination. It is necessary to test drill a site to determine the position of a cavity and to pump the well to determine its potential yield. To illustrate the uncertainty of the development and yield of a well in a limestone, figure 4 shows three wells. Well 1 is successful, having penetrated two solution cavities carrying ground water, the lower cavity saturated the year around. Well 2 is partly successful, having penetrated a cavity carrying water during a greater part of the year. When water levels are high its yield is satisfactory, but during the late fall when water levels are low the well may go dry. Well 3 failed to penetrate a large water-bearing opening, and is therefore dry.

Although the limestones may contain openings at great depths, if adequate water is not developed at a depth of 150 to 200 feet in the valley area in the vicinity of Huntsville, generally it is more economical to select another site and drill a second well. Drilling costs increase with depth, the quality of water becomes poor below the Chattanooga shale, and the openings in the limestone become fewer and farther apart.

The amount of water available from a well or spring in a limestone aquifer is closely related to the precipitation. At Huntsville the average rainfall is 47 inches per year. A correlative study of the flow of Huntsville Spring with the daily rainfall in the vicinity of the spring shows this relationship well. There is a lag of 24 to 48 hours from the time of the rainfall to the time of increase in flow of the spring. The highest annual flow is during the spring or rainy season, and sometimes a secondary high occurs in July and August during the period of summer rainfall. The period of low flow is from late September through early December. Water levels in wells in the area show this same relation; being low in the late fall and early winter.

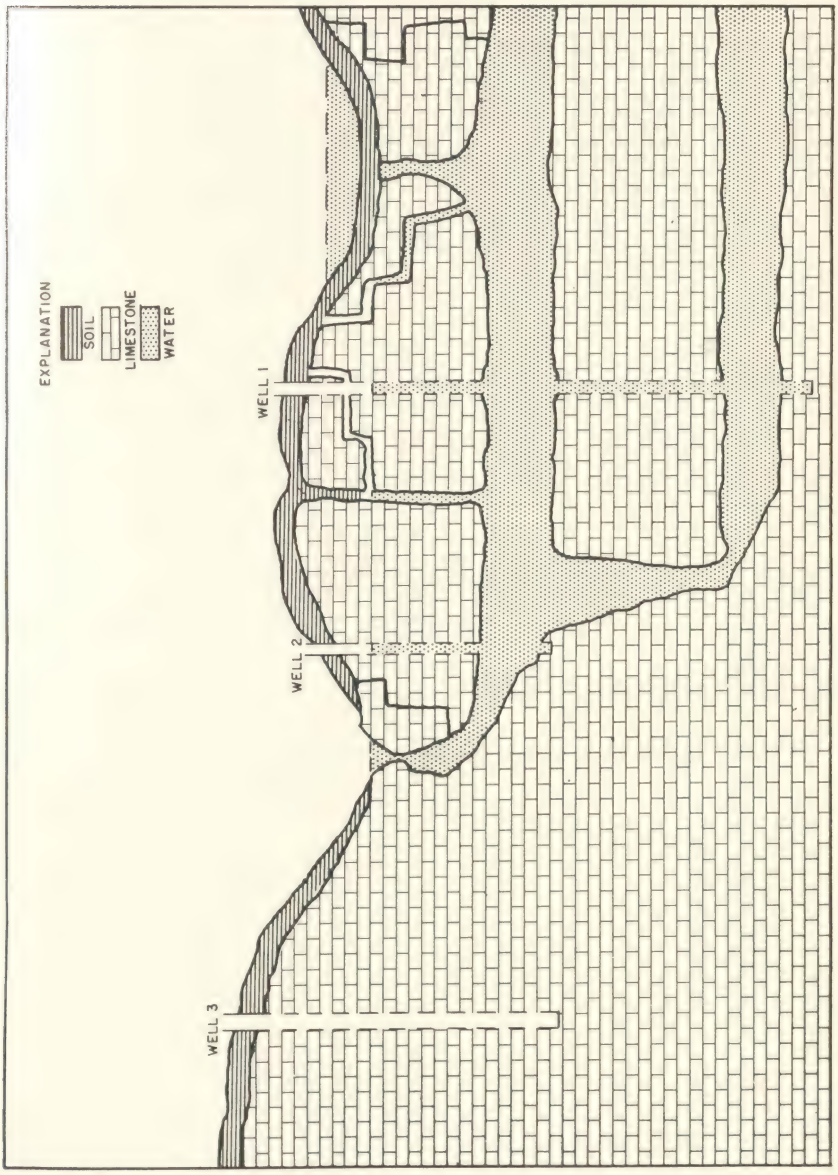

Figure 4.—Section showing occurrence of ground water in solution cavities in an area underlain by limestone, and three hypothetical wells, one successful, two partly successful, three dry.

Drainage Wells

In the rolling valley north of the Tennessee River in southern and central Madison County many sinkholes and shallow ponds interrupt surface drainage. These ponds are more or less characteristic of the area of outcrop of the Tuscumbia limestone. Drainage throughout a great part of this area is subterranean.

As previously stated, the storage or discharge capacity of a limestone is directly dependent upon the development of solution cavities. Limestones similar to the Tuscumbia are well jointed and extensively cut by solution cavities, which form excellent water reservoirs having large capacities. Water falling on the land surface percolates through the soil into the openings of the rocks to the water table. Where sinkholes are open and connect with the underlying solution cavities in the rocks, water drains rapidly into subterranean channels. At some localities, through weathering of the bedrock, the surficial openings in the sinks have been plugged by impermeable clayey soil. At such places these ponds are catchment basins for rainfall, alternately filling and then drying by evaporation and slow downward seepage of water. During periods of heavy rainfall the ponds fill and in some places overflow. The ponds in some localities inundate much land which could be used for cultivation.

In a year of normal rainfall the sink ponds are filled about the latter part of November and remain full until some time in May. During the summer at times of unusually high precipitation the ponds fill and remain full for several days or a week or more, depending upon the climatological conditions at the time. In many places the ponds are filled with water when the groundwater levels are low. At such times these ponds could be drained successfully.

There is a close relation between water levels in sink ponds and in adjacent limestone wells. Water levels in wells and sinks that fluctuate with the water table may be compared with water levels in ponds to determine if the pond is hydrologically connected with the underlying solution cavity system. If groundwater levels are lower than the water levels in the pond to be drained, vertical drainage would be successful. Vertical drainage by wells will be successful only in areas underlain by cavernous limestone, or some other highly permeable formation, and

then only where the water table is sufficiently low that a drainage well or wells can carry away surplus water.

An example of successful vertical-drainage wells is found at Chase Nursery, in the northwest corner of the area of this report, where two ponds of approximately 15 and 30 acres are drained by wells. In each of these ponds a drilled well 6 inches in diameter and approximately 60 feet deep is near the center in the low point of the pond. The wells are constructed with 6-inch casing set on top of solid limestone. One well has a slotted casing at the top through which the water drains. The other well is open and subject to stoppage by debris.

Caution is necessary in the locating of drainage wells because of the possibility of polluting existing water supplies. It is likely that domestic, industrial, and municipal wells adjacent to or in the area of a pond will be contaminated by the drainage of the pond through a vertical drainage well.

Quality of Water

Ground water in the Huntsville area is derived from rainfall supplemented by an occasional snowfall. Water that falls as rain or snow contains only small amounts of dissolved matter, but when the water reaches the ground it begins at once to dissolve mineral matter from the soil and bedrock. The most common substances in ground water are the salts of the common basic elements such as sodium, potassium, calcium, magnesium, iron, and aluminum. The amount and kind of dissolved matter contained in ground water differ greatly from place to place, depending upon the type and amount of organic material in the soil zone, the type of rock through which or over which the water moves, and the length of time the water is in contact with them.

The chemical quality of water may limit its use for domestic, municipal, and industrial supply. In general, domestic and municipal supplies should contain less than 500 parts per million of dissolved solids, and not more than 250 parts per million of chloride, 250 parts per million of sulfate, and 125 parts per million of magnesium. Total hardness should not exceed 150 parts per million because of soap-consuming properties, and fluoride in excess of 1.5 parts per million may cause mottled

enamel on teeth of young children (Public Health Reprint 2697).

Various industrial users place certain additional restrictions on a water supply. Hardness is of primary importance since an excessively hard supply greatly increases the soap consumption, and usually results in the formation of boiler scale. Industries such as laundries, textile mills, bleaching, dyeing, soap, tanning, and certain chemical industries require soft water for efficient operation. Water furnished a public or industrial user should not be corrosive. Oxygen, carbon dioxide, or free acid in a water will cause deterioration of the pipes, containers, or boilers and result in the appearance of red water due to solution of iron. Industrial and municipal water should contain not more than 0.3 part per million of iron and should also be free from suspended matter, color, taste, and odor. Some industries need a water of low constant temperature for cooling. If these properties are lacking, treatment is necessary, which increases the cost of water.

The Tuscumbia limestone and Fort Payne chert underlie a major part of central and southern Madison County. Nearly all the springs and wells in the area of this report obtain water from these formations. Calcium is easily dissolved by water percolating through these limestones and, therefore, the water of the area is generally high in calcium. Other common minerals in the water are sulfate, chloride, nitrate, bicarbonate, and iron.

The water from wells and springs in the Fort Payne chert and Tuscumbia limestone is of similar chemical quality. Twelve analyses were made of samples of water from wells or springs in the Tuscumbia limestone. With two exceptions—Chase well (8), which is probably developed in the upper part of the Tuscumbia limestone, and the Roper Floral Co. shallow well (57), 36 feet deep—the waters are similar in chemical character. Total hardness ranged from 95 to 155 parts per million in well water and from 58 to 144 parts per million in spring water. Up to 12 parts per million of nitrate was contained in well water, and from 1 to 8.1 parts per million in spring water. The iron content in well and spring water ranged from 0.02 to 0.16 part per million and bicarbonate from 110 to 372 parts per million, but in most wells was less than 175 parts per million. Chloride in both well and spring water ranged from 1.6 to 14 parts per million, whereas fluoride in general was not present. One ex-

ception was water from well 90 which contained 3.6 parts per million of fluoride.

Cold Spring (3) atop Monte Sano flows from the Bangor limestone. The water from this spring is lower in mineral content, and contains approximately one-half as much total hardness as water from the underlying Tuscumbia limestone.

An analysis of water from a well (56) at the Roper Floral Co., 525 feet deep and developed in limestone below the Chattanooga shale, shows excessive mineral content. Water from this well contained 2,960 parts per million of dissolved solids, 1,725 parts per million of total hardness, 921 parts per million of bicarbonate, and 735 parts per million of sulfate. The water from this well and others in the area that penetrate the Chattanooga shale or formations below yield water having a sulphurous odor.

Tables 2 and 3 list certain chemical constituents of the ground waters of the area.

Huntsville Municipal Supply

Of primary importance in the early location and development of Huntsville was Big Spring. At this spring the first municipal waterworks in the State of Alabama and one of the earliest in the United States was constructed in 1823. The system consisted of a wooden reservoir attached to the end of the courthouse from which water was distributed through cedar logs about 8 feet long made into conduits by a hole being bored through the center of each log. These pipes were tapered and joined together, being bound in place by iron bands. (See pl. 2.) Early pumping of the spring was by means of a water turbine and a 9-inch pump which forced water into the reservoir (Betts, 1916).

Plate 3A shows Huntsville Spring about 1850. Improvements made between that time and about 1862 are shown by Plate 3B.[8]

One of the earliest published measurements on Huntsville Spring is recorded in the second biennial report on the geology of Alabama by Michael Tuomey, issued in 1858. Since that time various measurements of discharge and temperature have been made. A list of these measurements or references to them, which is believed to be complete and in chronological order, is as follows:

[8]Pictures furnished by G. W. Jones & Sons, Huntsville, Ala.

151044

Table 2. Analyses of Water From Wells

in the Huntsville area, Alabama

Well Number	8[1]	35[1]	55[1]	56[2]	57[1]	66[1]	74[1]	90[1]
Silica (SiO_2)	.....	.....	.....	209	.....	.....	.....	.....
Iron (Fe)	0.59	0.07	0.10	0.16	0.38	0.07	0.03	0.03
Calcium (Ca)	.....	.....	.....	346	.....	.....	.....	.....
Magnesium (Mg)	.....	.....	.....	185	.....	.....	.....	.....
Sodium (Na)	.....	.....	.....	134	.....	.....	.....	.....
Potassium (K)	.....	.....	.....	33	.....	.....	.....	.....
Bicarbonate (HCO_3)	69	144	127	921	33	110	168	372
Sulfate (SO_4)	2	2	4	735	1	1	10	6
Chloride (Cl)	8	6.5	6.5	383	12	7	10	14
Fluoride (F)	.0	.0	.0	.....	.0	.0	.0	3.6
Nitrate (NO_3)	14	2.4	12	Trace	33	7.3	7	.0
Total hardness (soap)	66	123	106	1725	44	95	155	152
Dissolved solids	.....	.....	.....	2960	.....	.....	.....	.....
Date of collection:	11-13-48	11-10-48	11-12-48	8-6-45	12-10-43	11-13-48	11-12-48	11-12-48

[1]Analysis by U. S. Geological Survey.

[2]Analysis by Picard Testing Laboratories.

Table 3. Analyses of Springs in the Huntsville area, Alabama

(Analyses by J. Y. Geurin and Margaret D. Foster. Parts per million)

Spring Number	2	3	4	10	12
Silica (SiO_2)	----	----	15	13	----
Iron (Fe)	0.02	0.04	0.06	0.04	0.03
Calcium (Ca)	----	----	39	30	----
Magnesium (Mg)	----	----	5.5	4.6	----
Sodium (Na)	----	----	1.4	1.4	----
Potassium (K)	----	----	.6	.7	----
Bicarbonate (HCO_3)	164	57	129	103	156
Sulfate (SO_4)	4	9	5.3	5.8	10
Chloride (Cl)	7	9.5	1.7	1.6	9.5
Fluoride (F)	.0	.0	----	----	.0
Nitrate (NO_3)	4.5	1	7.3	5.8	8.1
Total hardness (soap)	144	58	120	94	140
Dissolved solids	----	----	139	115	----
Date of collection:	11-13-48	11-13-48	7-15-29	7-16-29	11-12-48

Plate 2. Cedar log conduits used in original water system.

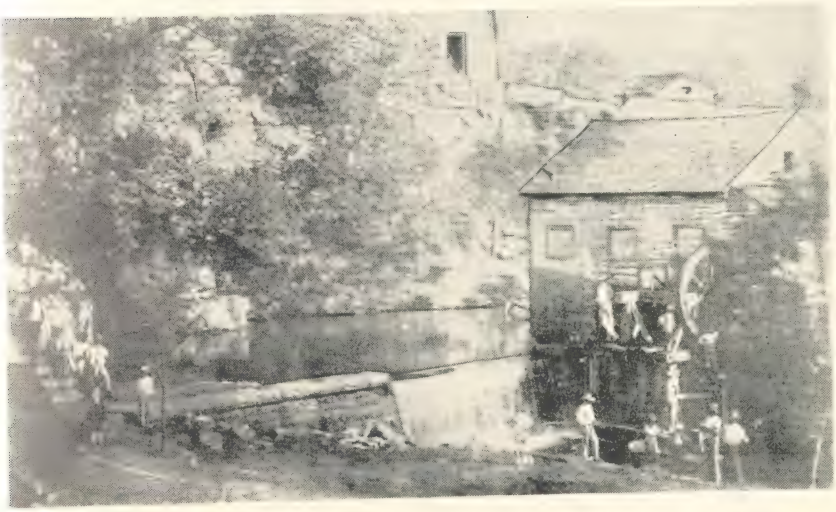

Plate 3A. Huntsville Spring and pumping station about 1850.

Plate 3B. Huntsville Spring and pumping station about 1862.

Date of Measurement	Publication authority	Type of record	Temperature
1858	Tuomey, Second Biennial report	.....	60.8
1896	McCalley, Report on valley regions	.....	59.47
Nov. 12, 1928 to Sept. 30, 1929	Water-Supply Paper 683 (1931)	Continuous daily discharge record	60.8
Oct. 1, 1929 to Sept. 30, 1930	Water-Supply Paper 698 (1932)	do.	60.8
Nov. 12, 1928 to Mar. 31, 1930	Ground waters of northern Alabama (1933)	do.	60.8
Oct. 1, 1930 to Sept. 30, 1931	Water-Supply Paper 713 (1933)	do.	60.8
Oct. 1, 1931 to Mar. 31, 1932	Water-Supply Paper 728 (1934)	do.	60.8
Nov. 12, 1928 to Mar. 31, 1932	Water-Supply Paper 677 (1936)	do.	60.8

The first detailed investigation of Huntsville Spring begun in November 1928 was completed in March 1930. A summary of the data obtained at that time and published in 1933 (Johnston, pp. 44-46), is as follows:

> On November 12, 1928, an automatic water-stage recorder was installed above the weir . . . , and this recorder has remained in service up to the present time. From the time of installation until the end of March 1930, the maximum daily discharge recorded was on March 23 and 24, 1929, when the spring flowed at the rate of 45 cubic feet a second, which is about equal to 29,000,000 gallons a day. The minimum daily discharge recorded was on August 25 to 31, and September 7 to 12, 1929, when the average rate of flow was only 12 cubic feet a second, or about 7,800,000 gallons a day. . . .
>
> The discharge peak of March 23 and 24, 1929, came in a season of low evaporation and was a result of 2.2 inches of rain on March 14, followed by 1.25 inches on March 22 and 1.6 inches on March 23. Conversely the low flow of late August and early September, 1929, was the result of

subnormal rainfall and heavy evaporation and transpiration during July and August.

During dry seasons much of the discharge of the spring comes from water stored in the smaller openings during wet weather. This stored water gradually drains into the main solution openings during long periods of dry weather.

As precipitation records by hours are not available, it is impossible to state exactly the lag between precipitation and the discharge peak of the spring. This lag appears, however, to vary between a few hours and 1½ days. Obviously such a variation, depending upon the concentration and position of the rainfall, the degree of moisture of the soil, the amount of water in storage in the rocks, and other factors, is to be expected.

In that same report an estimate of the area drained by Big Spring was made by comparing the mean annual spring discharge, precipitation, evaporation, and transpiration. The latter factor was determined for the drainage basin of Bear Creek in Franklin County in an area similar to that around Big Spring. The area, computed to be approximately 12 square miles, lies mainly north of Huntsville.

A study of the data collected with the water-level recorder from 1928 to 1932 was published in Water-Supply Paper 677, "Ground water in south-central Tennessee," by Charles V. Theis. In this report the relation of spring discharge during various drought and normal years is described. A part of the discussion on Huntsville Spring included therein is as follows:

The record of the daily discharge of Huntsville Spring, in Alabama, about 15 miles south of Lincoln County, from November 1928 to March 1932, is available. The record of this spring during the field season in which the data of this report were collected, the succeeding year, also a drought year, and the preceding more normal year is given graphically in plate 5. The minimum discharge during the dry season of 1929 was 12 second-feet, occurring in August and September; in 1930 it was 5.4 second-feet, occurring in November; and in 1931 it was only 3.2 second feet and occurred in November. The greater ground-water deficiency in 1931 is again demonstrated. The relationship between the fluctuations in discharge and the precipitation should

be noted; it is evident that the amount of low-water flow in the dry summer season is largely dependent on the amount of precipitation during the preceding winter period, that during the winter the discharge in general immediately increases after a heavy rain, and that in summer even heavy rains have little effect upon the discharge.

These data seem to the writer to give a basis for forming a tentative opinion that ground-water discharge was smaller in 1930 than normal, perhaps about 80 percent of normal, but it was perhaps 25 percent greater than the minimum ground-water flow that may be expected.

Plate 5 of Water-Supply Paper 677 is reproduced in this report as Plate 4. It shows the relation of ground-water discharge to precipitation for the period November 1928 to March 1932.

During the late fall of 1942 the discharge of Huntsville Spring dropped below or became approximately equivalent to the amount of water necessary for the municipal supply. City officials requested C. W. Carlston of the Ground Water Branch office, through Dr. Stewart J. Lloyd, Assistant State Geologist, to make an investigation. In November 1942, through the cooperation of the Alabama office of the Surface Water Branch, new staff gages were installed and discharge measurements were made at the lower weir of the spring. On January 1, 1943, periodic readings were begun of the discharge over the lower weir and correlated with pumpage and precipitation records for the area. On March 25, 1945, a continuous weekly water-level recorder was reinstalled at the lower weir and has been maintained to the present time.

Plate 5 shows the recorder installation and the upper pool of the spring. The plan of the Huntsville waterworks is shown in figure 5.

From January 1, 1943, through March 31, 1948, the maximum daily discharge recorded, on February 14, 1948, was 40.4 second-feet, which is equivalent to 26,156,000 gallons a day. The minimum daily discharge for this same period was recorded from December 15 to 25, 1944, when pumping from the spring kept the water from flowing over the lower weir. The minimum flow at this time is estimated to have approached 3 second-feet or the minimum predicted by Theis (Water-Supply Paper 677).

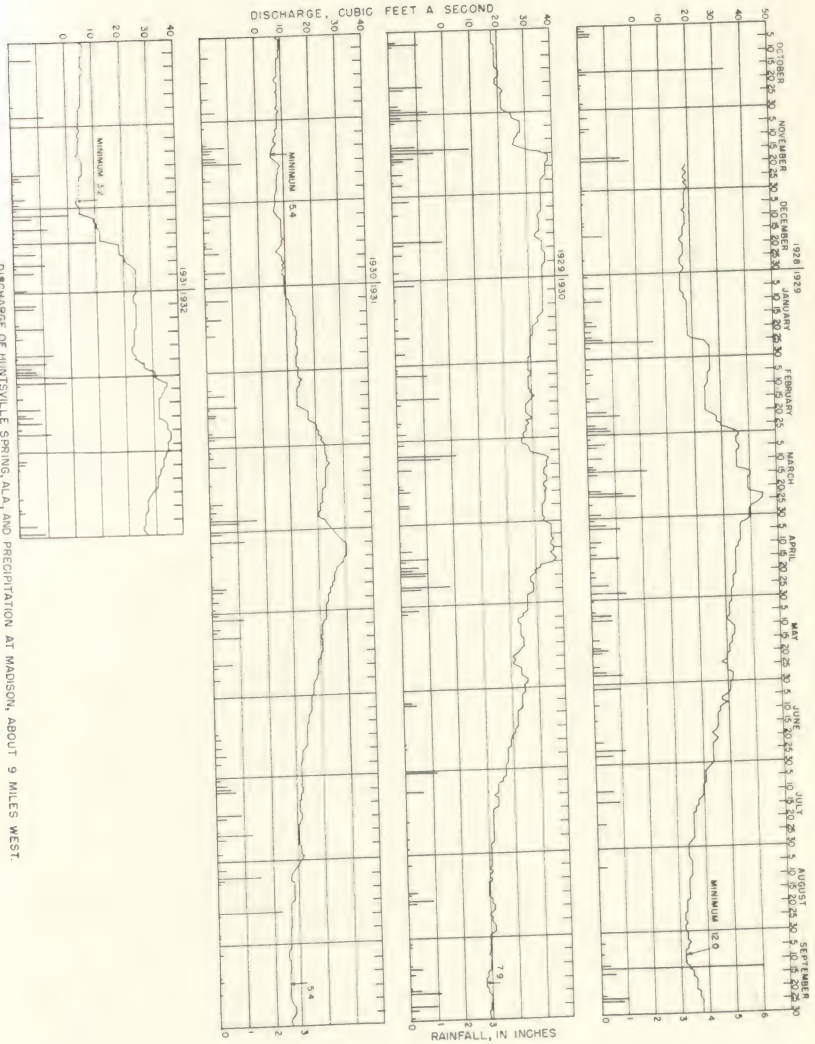
DISCHARGE, CUBIC FEET A SECOND
RAINFALL, IN INCHES
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
1928
1929
1930
1931
1932
MINIMUM 12.0
MINIMUM 5.4
MINIMUM 3.9
7.9
5.4
DISCHARGE OF HUNTSVILLE SPRING, ALA., AND PRECIPITATION AT MADISON, ABOUT 9 MILES WEST.
(FROM W.S.P. 677, PL. 5)

Plate 4.

Plate 5A. Recorder installation and lower weir at Huntsville Spring.

Plate 5B. Upper pool and fountain at Huntsville Spring.

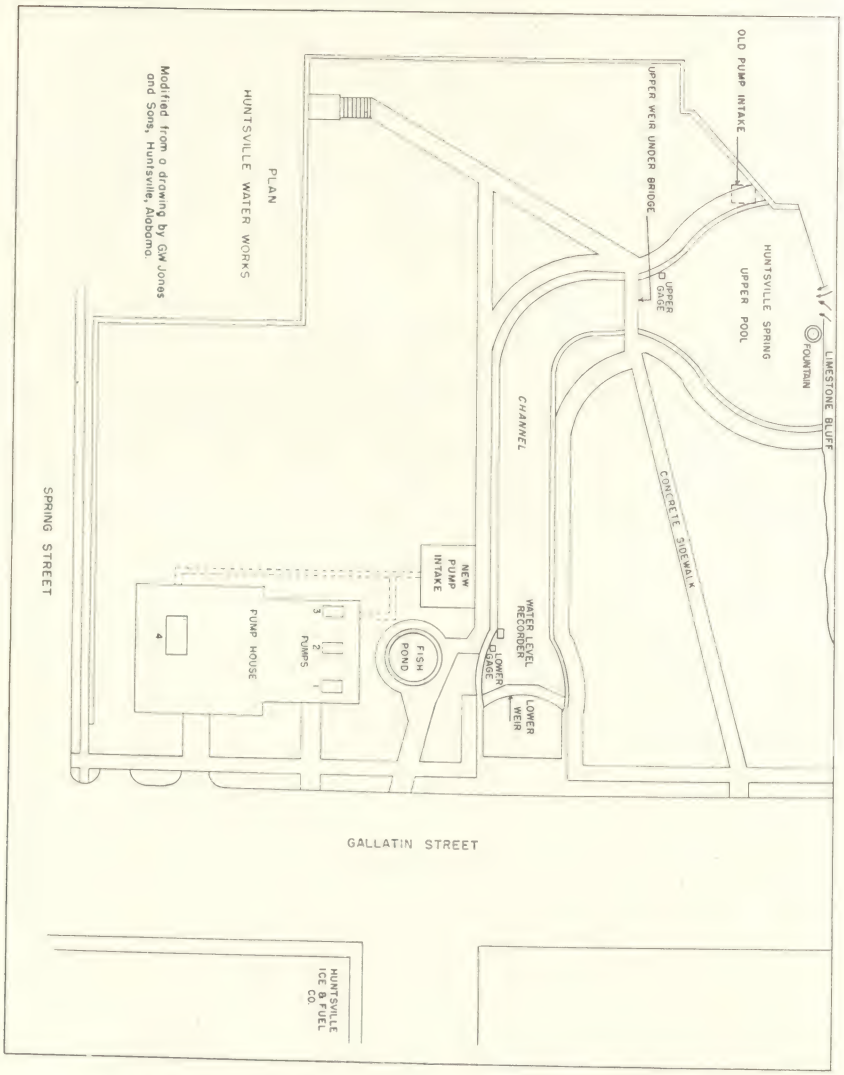

Figure 5. Diagram of Huntsville Spring and pumping plant.

During the 5-year period in which Huntsville Spring has been under investigation an interesting series of hydrologic data has been obtained. In the upper parts of plates 6 to 12 pumpage for municipal use is plotted in million gallons a day; in the middle sections the total discharge (discharge over the lower weir plus pumpage) for Huntsville Spring is recorded; and in the lower sections precipitation, in inches, at the Huntsville station of the U. S. Weather Bureau is plotted for reference to discharge of the spring.

Pumpage

The City waterworks for the most part operates two electrically driven centrifugal pumps. The no. 1 pump was originally reported to yield 3,500 gallons a minute and the no. 2 pump 2,500 gallons a minute. A third centrifugal pump driven by a gasoline engine is used as an auxiliary and has a reported yield of 2,300 gallons a minute. The water supply flows by gravity from Huntsville Spring to an intake basin for the pumps (see fig. 5) and from there is pumped into the distribution system and a 564,000-gallon elevated standpipe. The general daily pump operation schedule for the 1943-48 period includes the operation of the no. 2 pump during the night and the no. 1 or large pump throughout the day, or during the period of greatest demand. A fourth pump with a reported capacity of 5,350 gallons a minute and a new pump intake were installed at the spring during 1949 and 1950. However, they were not in use at the time of this investigation, (see fig. 5).

The curves representing pumpage are similar throughout the 5-year period of observation, with minor exceptions of low use during unusual climatic conditions and high use on certain days when large quantities of water were pumped for municipal and industrial use or fire protection. A period of low pumpage for municipal use is from November through May, and a period of higher pumpage from June to October. October and May are transitional months during which pumpage may be either high or low, depending on the weather.

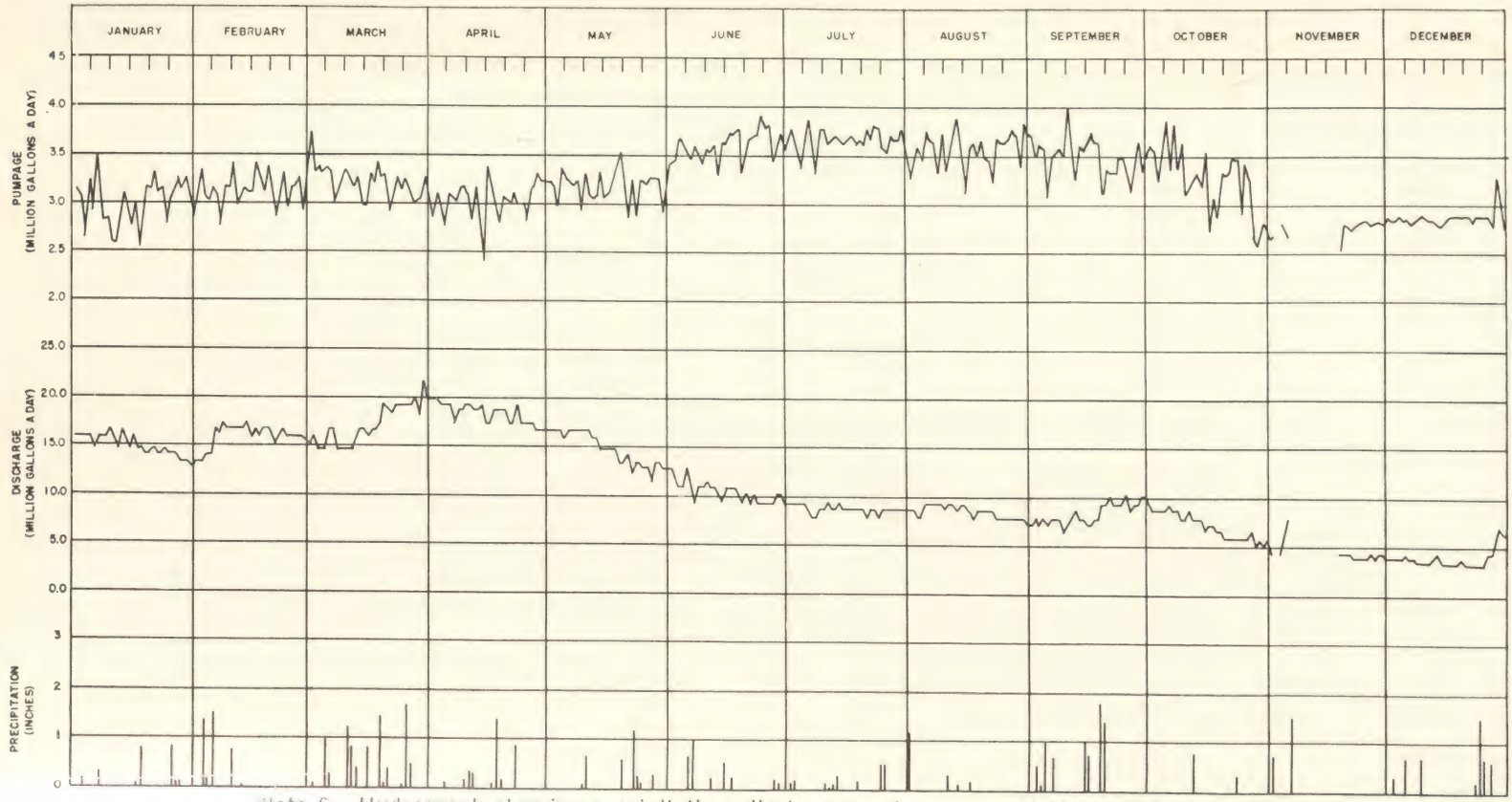

Plate 6. Hydrograph showing precipitation, discharge, and pumpage at Huntsville Spring, 1943.

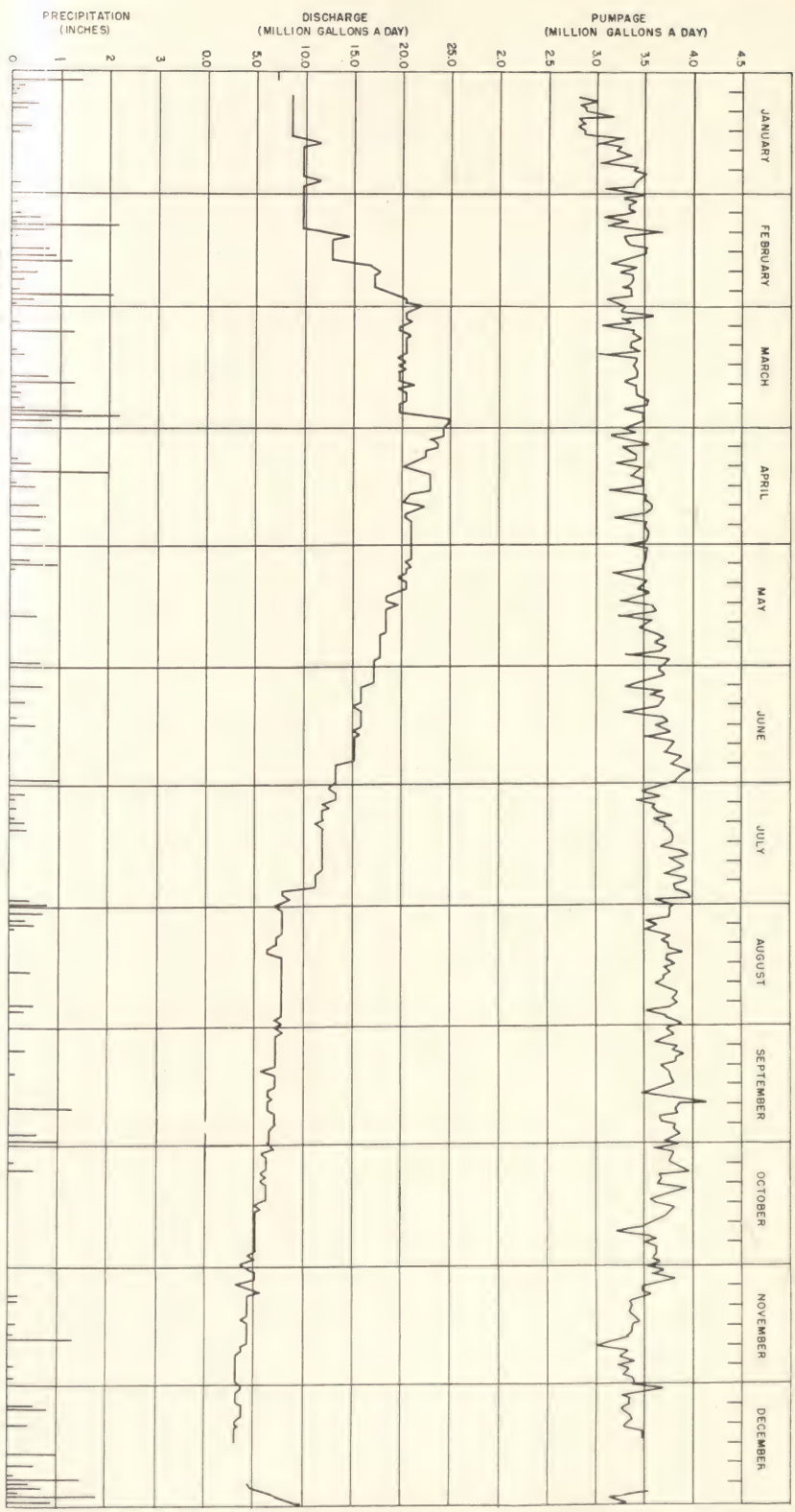

Plate 7. Hydrograph showing precipitation, discharge, and pumpage at Huntsville Spring, 1944.

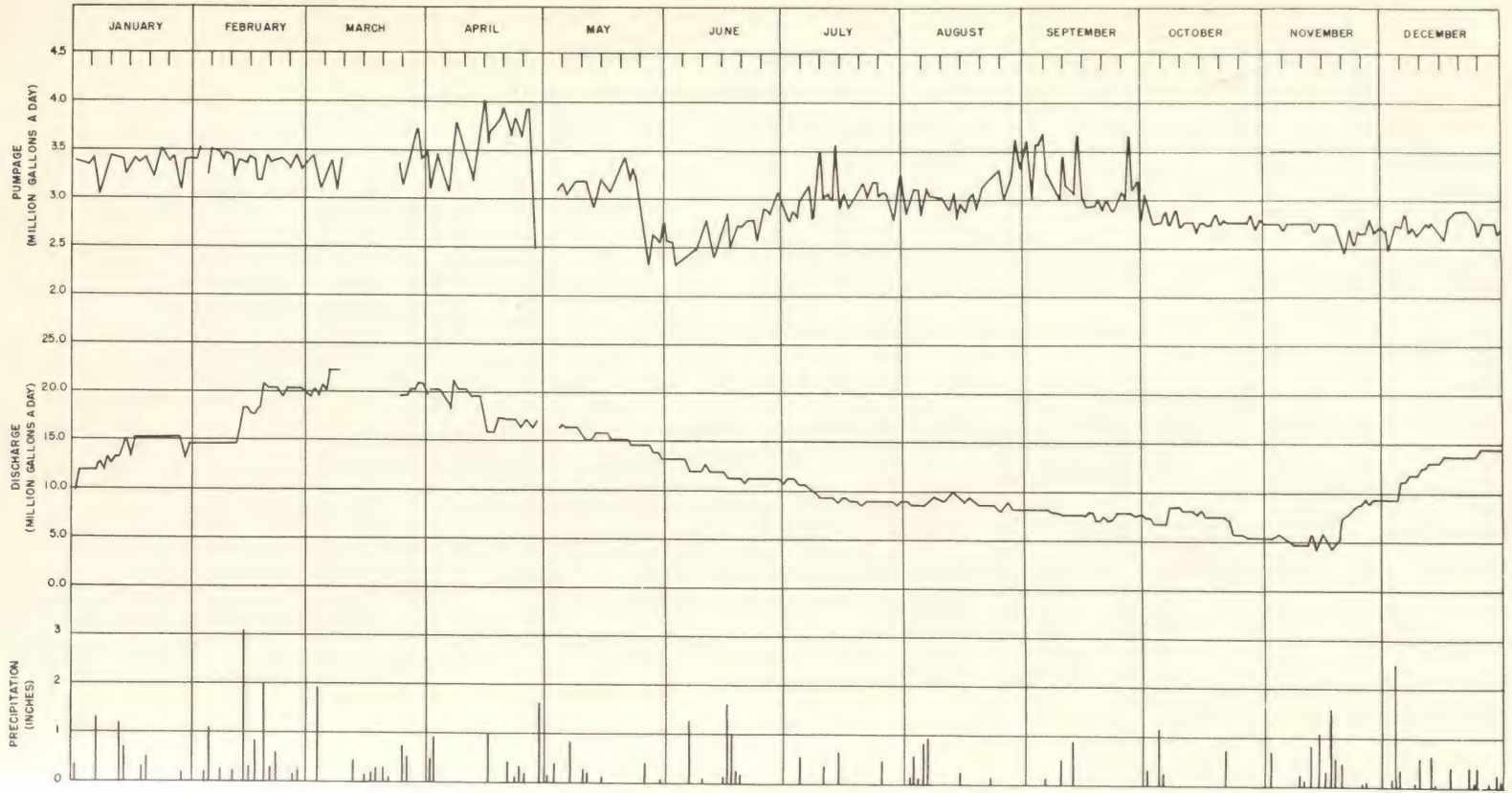

Plate 8. Hydrograph showing precipitation, discharge, and pumpage at Huntsville Spring, 1945.

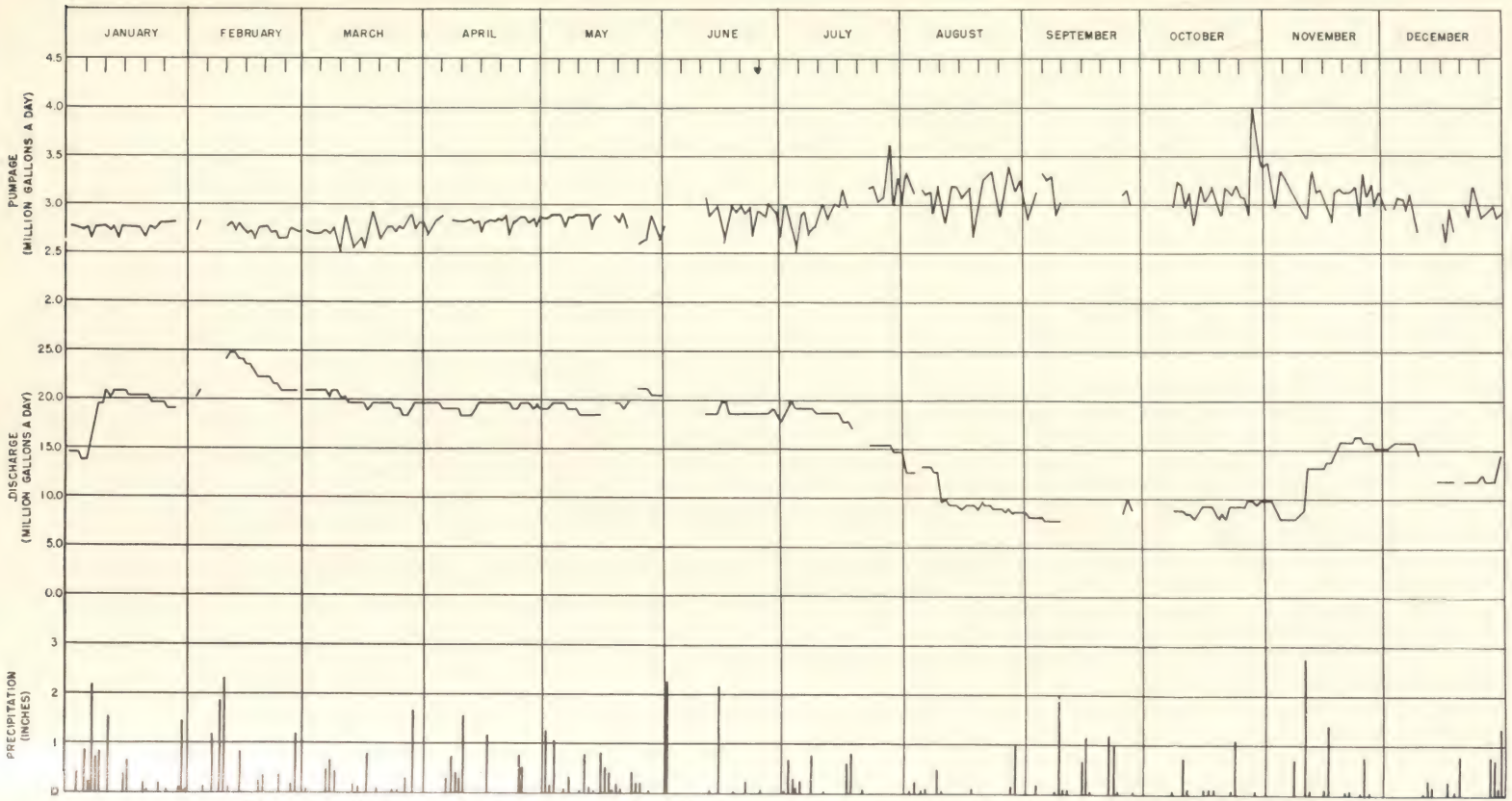

Plate 9. Hydrograph showing precipitation, discharge, and pumpage at Huntsville Spring, 1946.

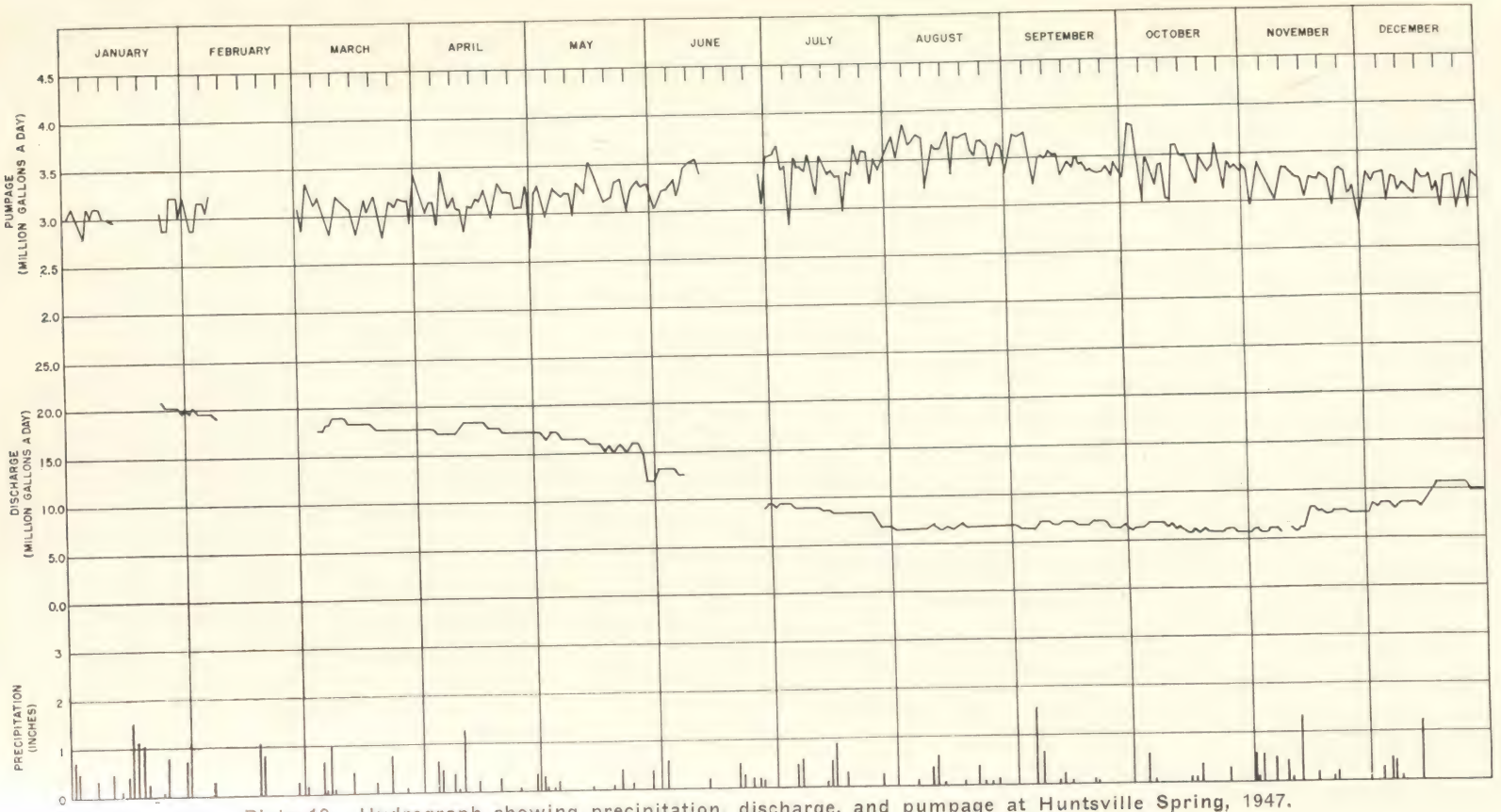

Plate 10. Hydrograph showing precipitation, discharge, and pumpage at Huntsville Spring, 1947.

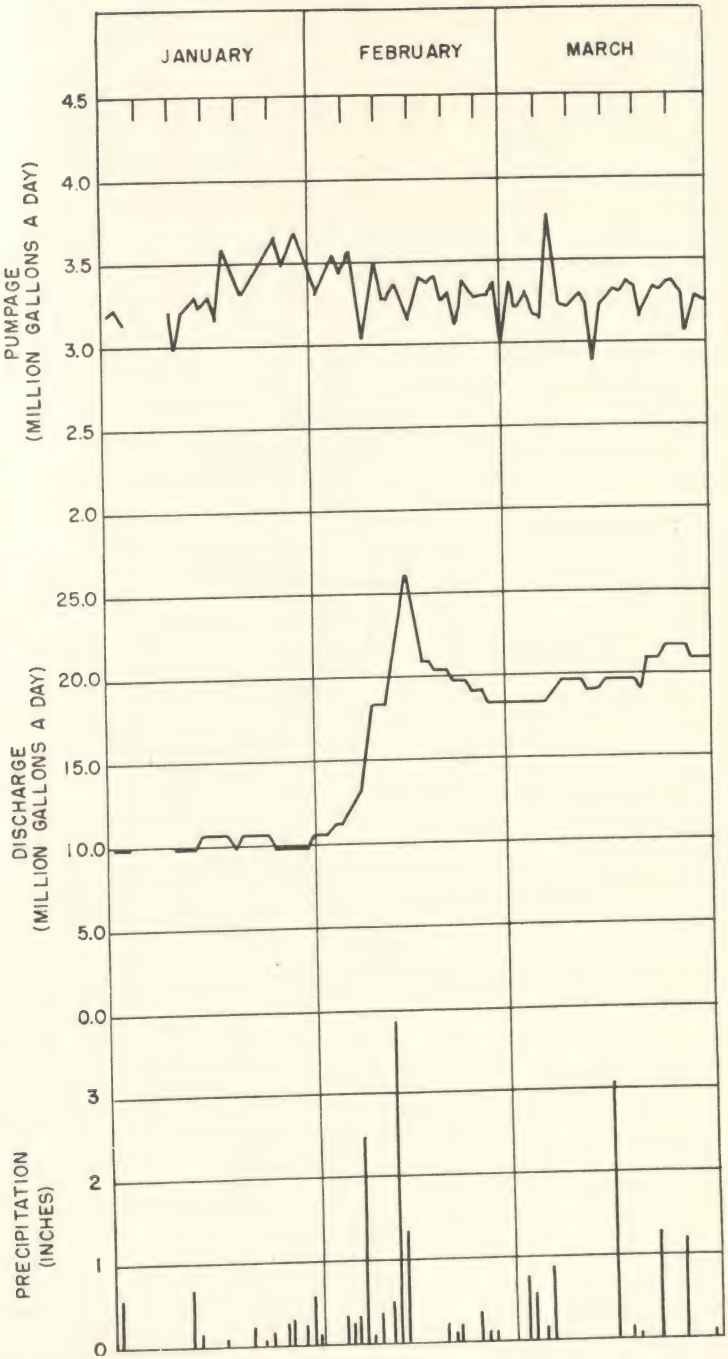

Plate 11. Hydrograph showing precipitation, discharge, and pumpage at Huntsville Spring, 1948.

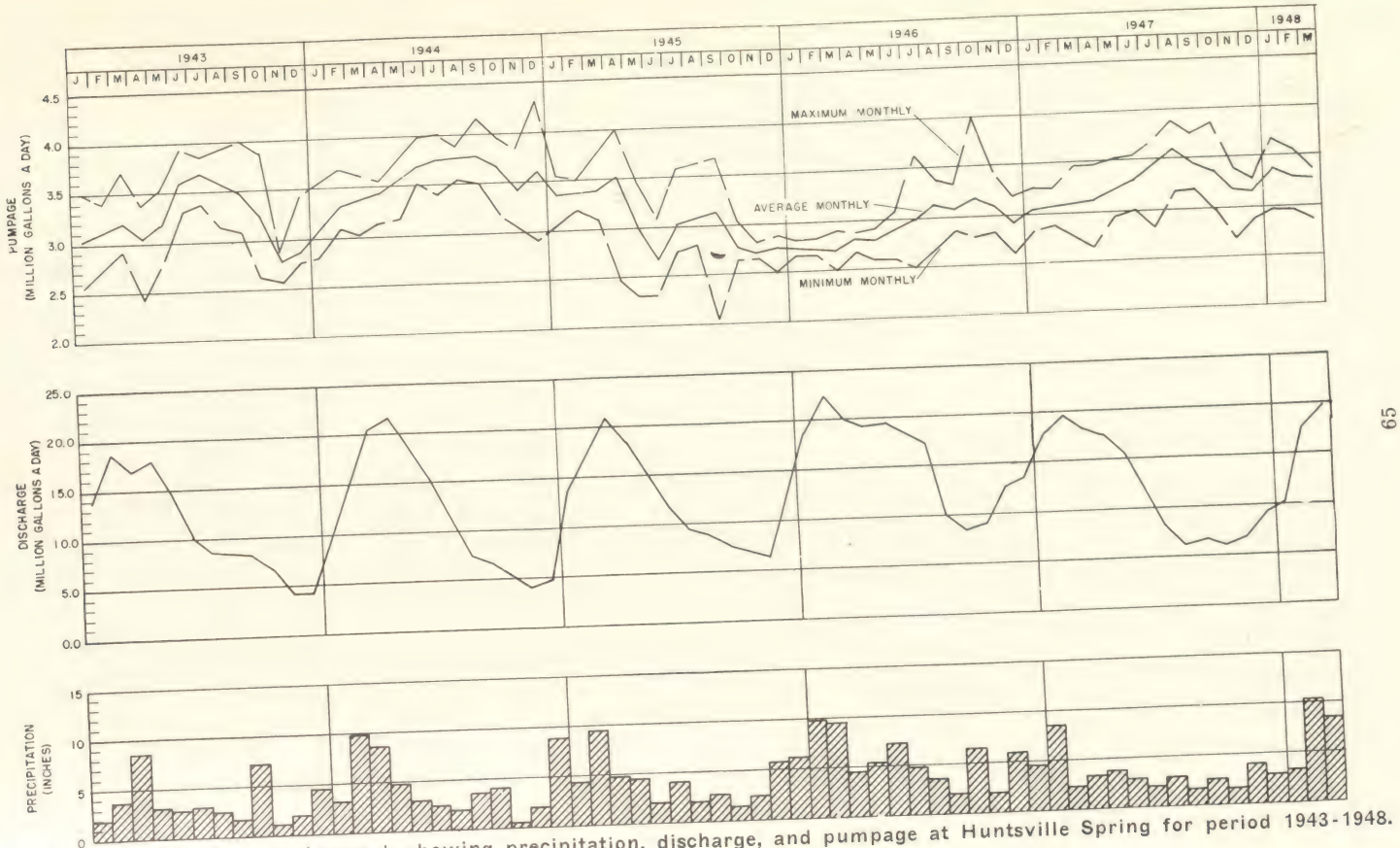

Plate 12. Summary hydrograph showing precipitation, discharge, and pumpage at Huntsville Spring for period 1943-1948.

Pumpage from Huntsville Spring gradually increased from about 2.5 to 3 million gallons a day during 1943 to about 4 million gallons a day in the summer of 1945. During 1945 the Pitometer Company made a survey of the Huntsville water system and found underground leakage in the amount of 896,000 gallons a day, and an additional leakage of 618,000 gallons a day from fire hydrants and meter connections. The subsequent stoppage of leaks from the system during 1945 and 1946 shows up markedly in the reduction of pumpage shown on plate 8. The general increase in municipal use of water continued, however, until by 1948 about 4 million gallons of water were being pumped daily, thereby using for municipal use the 1,500,000 gallons formerly lost through leakage from the system.

In general, during the winter, spring, and summer the pumpage of water from Huntsville Spring ranges from 2.5 to 4 million gallons a day. During this period the spring flow is more than adequate to meet the demand. During the late summer and fall the municipal use of water reaches a peak, which unfortunately comes at a time of minimum discharge from the spring. To date, during years of normal and above-normal precipitation and spring flow there has been adequate discharge from the spring to meet the City's requirement for water. However, during a year of drought and subsequent period of low flow from the spring a water shortage has existed. Such water shortages occurred during 1943 and 1944. The great demand for water during the summer of 1944, a year of normal rainfall but a year following the greatly below normal precipitation of 1941, 1942, and 1943 (see fig. 6), extended into the fall, the period of minimum flow from the spring. As a result, restrictions on municipal use of water had to be enforced. During this period no water flowed over the lower weir and pumpage was from storage in the upper pool of the spring plus the available discharge from the spring.

Method of Determining Spring Flow

Discharge measurements of water over the lower weir were correlated with periods of operation of the three city pumps to determine the flow of the spring. Great variations in pump discharge were found to occur between the starting time and stopping time of the pumps. These variations in pump dis-

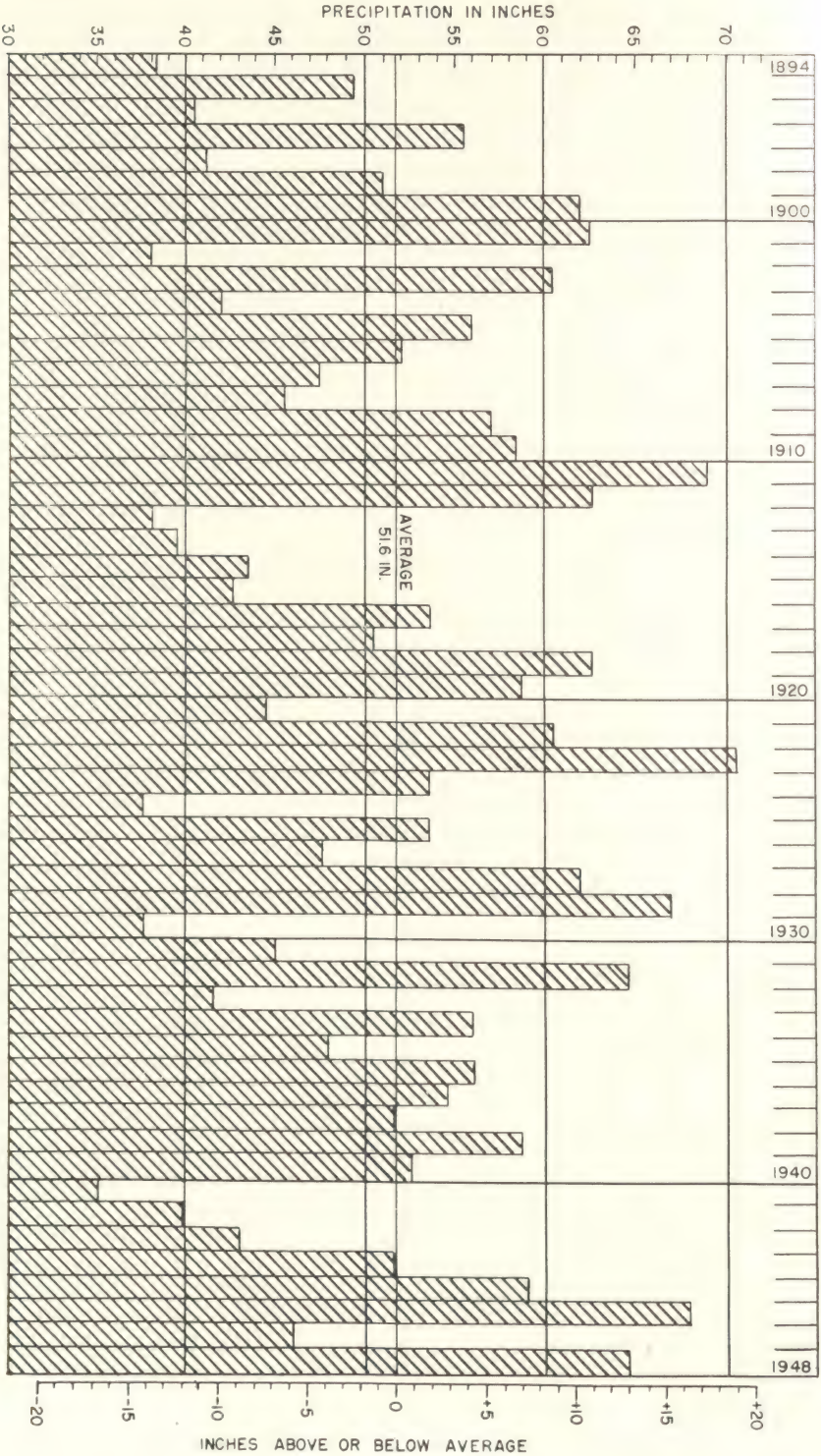

Figure 6.—Precipitation at Huntsville, Alabama, for period 1894-1948

charge are caused mainly by different pressures on the water system, and by the time necessary for the pumps to reach maximum efficiency. It was discovered, however, that after about 2 hours static conditions of pumping were established and the response of the upper pool and lower channel reached equilibrium. Under such a condition daily measurements of the spring were made by computing the flow over the lower weir and adding to it the pumpage at the time of the gage-height reading.

This method of spring measurement had to be adopted rather than that of choosing high points on the recorder chart as total discharge points for the spring (method used in the earlier study, 1929 to 1932),[9] because at few times during the period of present observations did the pumps stand idle long enough for a static condition in spring flow to prevail.

Several factors influence the accuracy of measurement of the discharge from the spring. Measurements at the beginning of this study made by E. B. Rice, Surface Water Branch, showed the large no. 1 pump at the Huntsville Waterworks to vary from 3,430 to 3,760 gallons a minute, but to have a normal capacity of 3,500 gallons a minute. The small, or no. 2, pump measured at the same time discharged from 2,120 to 3,580 gallons a minute, but had a normal capacity of 2,500 gallons a minute. The variation in discharge was believed to be caused by the difference in head pressure on the Huntsville water system, which ranges from 71 to 85 pounds.[10] The pumps are turned on and off manually, depending on the reading of the pressure gage at the plant. Although an accurate record of time of pump operation is kept by the operators, there has been no continuous or accurate means of keeping records of the amount of water pumped.

Recent measurements of the discharge from the pumps show that the no. 1, or large pump now yields 3,000 gallons a minute, and the no. 2, or small, pump yields 2,000 gallons a minute.[11]

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[9]Letter from F. M. Bell to C. B. Hardison, Jan. 30, 1945.

[10]Letter and report from E. B. Rice, Nov. 11, 1942.

[11]From report of Pitometer survey, letter, Polglaze & Basenberg, Jan. 21, 1950, determinations from recorder charts, showing differences in flow over lower weir in response to pumping, and from pumping test Jan. 6, 1950.

The difference in the reported capacities of the pumps at the time the observations on the spring were begun in 1943 and at the end of this period of observation in 1948 is great. No new pumps were installed during the period of observation, and the difference can be explained only by the change in the efficiency of the pumps. Because the accurate total daily discharge measurements were dependent on correct pumpage records, the records for the period of observation can be classed as only fair. They do show, however, the true fluctuations in spring flow, and are as accurate an index to the pumpage and use of water from the spring as can be determined. Capacities of 3,000 gallons a minute for the no. 1 pump and 2,000 gallons a minute for the no. 2 pump were used in compiling the Huntsville Spring discharge records for this report.

Some of the differences in the maximum and minimum discharge measurements of the spring during previous periods of observation and the present observation could be due to the use of different pump capacities in the computation of total discharge. The total discharge figures computed by using 3,500 gallons a minute as the capacity of the large pump and 2,500 gallons a minute as the capacity of the small pump would vary greatly with computations of total discharge based on capacities of 3,000 gallons a minute for the large pump and 2,000 gallons a minute for the small pump. A table showing these variations follows:

Table 4

Year	Date	Flow at rate of 2,500—3,500 gallons per minute	Flow at rate of 2,000—3,000 gallons per minute	Year	Date	Flow at rate of 2,500—3,500 gallons per minute	Flow at rate of 2,000—3,000 gallons per minute
		Maximum	Maximum			Minimum	Minimum
1943	3-30	22.650	21.777	1943	12-25	4.175	3.268
1944	3-29	26.876	24.863	1944	12-14	3.789	No flow over lower weir
1945	3- 7	25.961	22.227	1945	11-14	7.542	4.432
1946	2-11	27.523	24.863	1946	9- 8	9.319	7.859
1947	1-25	22.526	20.984	1947	11-12	8.994	5.725
1948	2-13	26.876	26.156	1943	1-11	10.386	9.992

Another variable in the accurate determination of discharge from Huntsville Spring affects the measurements taken during the present investigation and the earlier continuous records from 1929 to 1932. At a City Council meeting on October 14, 1919, the Huntsville Ice and Fuel Co. procured the right to withdraw water from Huntsville Spring.[12] Water used during the ice plant's operations is supplied by gravity flow from the pump intake at the upper pool of the spring through a 6-inch main about 350 feet long. No records have been maintained of the flow of water diverted in this manner, but as this main takes water above the lower weir and at the same point as the city pumps the amount should be added to the flow of the spring during both the earlier periods of observation and the present studies.

In continuing the study of the discharge of Huntsville Spring, a flow meter should be installed to keep an accurate record of the amount of water pumped from the spring. Some arrangement should be made with the Huntsville Ice and Fuel Co. to record the amount of water withdrawn through the 6-inch main at the City pump intake. Check measurements should be made below the lower weir every 6 months to determine the flow of the spring and to check the capacities of the city pumps in operation. One lower and one upper gage-height reading a week, at a time of stabilization or after a period of two hours' constant pumping by one of the pumps, should be entered on the daily pumpage charts. The recorder best adapted for the measurements is the Stevens Type F, with a gear ratio of 1 to 1, gage-height readings and time of reading to be recorded every week at the time of resetting. In addition, the flow of water pumped through the fountain should be determined and subtracted from the daily discharge measurements as this water is returned to the upper pool. (see pl. 5)

Characteristics of Spring Discharge

By plotting the average daily discharge by monthly periods, as in plate 12, a smooth line is shown which brings out the annual fluctuations of the spring. This graph shows a gradual increase in spring flow complementary to rainfall in the latter part of December, January, February, March, and April. During

[12]Minutes of Huntsville City Council, Oct. 14, 1919.

this period of recharge water progressively fills the openings below the land surface. Upon reaching a peak, generally in April, the spring's discharge gradually decreases during late April and May. Summer rains sometimes cause a secondary peak, as shown by the graph for 1946. Spring flow during July, August, September, October, and November decreases as the water stored in the smaller openings during wet weather is gradually depleted. This summary graph shows the lowest spring discharge during the fall or early winter.

Plates 6 to 11 show daily discharge measurements correlated with daily precipitation and pumpage. These graphs, though highly irregular with many discharge peaks and lows, correlate closely with the daily rainfall. At a time when the flow of the spring is high and the channels feeding the spring are near saturation, the reflection of a rainfall is very rapid, a matter of but a few hours. However, in the fall of the year when the spring discharge is low and the channels are not filled, it takes 24 to 48 hours for a period of rainfall to reflect itself in the discharge of the spring.

In reviewing the summary for the 5-year period of observation, plate 12, it can be seen that periods of low flow of the spring can be predicted. The precipitation data in figure 6 indicate that the period of low discharge from the spring is in the fall and winter of a year succeeding a drought year. This is confirmed by the records of low flow of the spring. A minimum flow of 3.2 second-feet was recorded from November 27 to 29, 1931, after the drought year of 1930, and again in December 1944 after 3 years of below-normal rainfall in 1941, 1942, and 1943. For the period December 15 to 25 pumpage equaled spring flow, and would have exceeded it if precautionary measures had not been taken. The rainfall data in figure 6 suggest that low flows of Huntsville Spring probably took place or did the year following the below-normal rainfall in 1894, 1902, 1913-14, 1925, 1931 and 1941-43.

SUMMARY

The Huntsville area of Alabama lies partly in the Cumberland Plateau section of the Appalachian Plateau and mainly in the Highland Rim section of the interior low plateaus. The geology and hydrology of the area are controlled largely by limestone of Mississippian age, particularly the Tuscumbia limestone and Fort Payne chert. Below the Chattanooga shale, which underlies the Fort Payne, ground water is highly mineralized. The structure of the area is relatively simple, the rocks dipping gently to the southeast.

The ground water of the area is only partly developed. Much additional ground water could be obtained from the full development of some of the larger springs in the area and from properly located wells. Huntsville Spring, however, is developed to the maximum extent, approximately 4 million gallons a day during periods of normal minimum flow. The city could supplement this supply with water from other large springs in the area, such as Brahan Spring, which flowed 8.928 million gallons a day on January 14, 1949, Byrd Spring, with a partial flow of 5.364 million gallons a day on January 14, 1949, and Acuff Spring, with a flow of 2.160 million gallons a day on July 10, 1929. The discharge of these springs varies greatly from wet to dry seasons and of course all springs and wells in the area are affected by periods of prolonged drought.

The quality of water obtained from most wells and springs in the area is satisfactory for ordinary use. The ground water is a calcium water with a total hardness of about 100 parts per million. Wells drilled below the Chattanooga shale encounter water too highly mineralized for ordinary use.

Table 5.—Well data from the Huntsville area of Alabama

Numbers correspond with those on Plate 1.
Type of well: B, bored; D, drilled; Dr, Driven; Du, Dug.
Use: D, domestic; Dr, drainage; Ind, industrial; Irr, irrigation; S, stock; Sch, school.

Method of lift: EP, electric pump; HP, hand pump; W, bucket and windlass.
Water-bearing formation: S, skeletal soil zone above limestone; T, Mississippian limestones, including Tuscumbia and Fort Payne chert; P, Pottsville formation; C, formations below the Chattanooga shale.

Well No.	Location	Owner or Name	Driller	Type of well	Depth of well (ft.)	Diameter of casing (in.)	Depth of casing (ft.)	Principal water-bearing formation	Water level			Date of measurement	Method of lift	Temperature °F.	Use	Remarks
									Description of Measuring Point (MP)	MP above land surface (feet)	Water level below (—) MP (feet)					
1	SW¼ NE¼ sec. 2, T. 3 S., R. 1 E.	A. W. White		Du	37.8	36		S	Top terra cotta pipe		—31.9	6-29-49	W		DS	Goes dry.
2	NW¼ SE¼ sec. 2, T. 3 S., R. 1 E.	A. W. White		D	55	6		T	Top of casing		—30.1	6-29-49	W	62.5	D	Not used. Iron and sulphur in water.
3	NE¼ NW¼ sec. 14, T. 3 S., R. 1 E.	Dr. Frank Jordan		Du	28.8	36		T	Top of casing	3	—15	6-29-49	W			
4	SE¼ NW¼ sec. 3, T. 3 S., R. 1 E.	T. W. Naugher		Du	86.5	36		T	Top of casing		—65.5	6-28-49	EP	63	D, Irr	
5	NE¼ NW¼ sec. 9, T. 3 S., R. 1 E.	Chase Nursery		D	75	6		T	Top of casing			11-12-48	HP		D	
6	NW¼ SW¼ sec. 9, T. 3 S., R. 1 E.	Chase Nursery		D	84	6		T	Top of casing			11-12-48	HP		D	
7	SE¼ SW¼ sec. 9, T. 3 S., R. 1 E.	Chase Nursery		Du	25	48		S	Top of casing		—15	11-12-48				
8	SE¼ NW¼ sec. 16, T 3. S., R. 1 E.	Chase Nursery		D	82	8		T	Top of casing		—25	11-12-48	EP	62	D, Irr	Yields 40 g.p.m. Analysis.
9	SW¼ NW¼ sec. 16, T. 3 S., R. 1 E.	Chase Nursery		D	65	6		T	Top of casing		—15	11-12-48				

10	NW¼ NW¼ sec. 16, T. 3 S., R. 1 E.	Chase Nursery	....	D	60	6		T	Top of casing			12- 2-48			Dr	Drains 30 acres.
11	SE¼ NE¼ sec. 17, T. 3 S., R. 1 E.	Chase Nursery	....	D	63	6		T	Top of casing		—38.2	12- 2-48			Dr	Could not be measured.
12	SW¼ NE¼ sec. 17, T. 3 S., R. 1 E.	Chase Nursery	....	D	62.5	6		T	Top of casing		—38.2	11-30-48			Dr	Drains approximately 15 acres.
13	NE¼ NE¼ sec. 17, T. 3 S., R. 1 E.	Chase Nursery	....	Du	65	48		S	Top of casing		—15	11-12-48				
14	SW¼ NW¼ sec. 18, T. 3 S., R. 1 E.	Alabama A & M	Roy Boling	D	154	6	62	T	Top of casing		—83	11- 8-48	EP	62	D, S, Irr	Yield 125 g.p.m
15	NW¼ NW¼ sec. 18, T. 3 S., R. 1 E.	Alabama A & M	....	D	154	6	65	T	Top of casing		—83	11- 8-48	EP	62	D, S, Irr	Yield 125 g.p.m
16	SE¼ SW¼ sec. 11, T. 3 S., R. 1 W.	W. H. Hinshaw	Hawley Dodson	D	105	6	90	T	Top of casing		—40	11- 9-48	EP	61	D, S	Analysis.
17	SE¼ NE¼ sec. 10, T. 3 S., R. 1 W.	Steven Brosemer	Hawley Dodson	D	130	6	50	T	Top of casing		—50	11- 9-48	EP	61	D	Analysis.
18	NW¼ SE¼ sec. 15, T. 3 S., R. 1 W.	Huntsville Wholesale Nurseries	....	D	125	6	38	T	Top of casing			11- 9-48	EP		D	
19	NW¼ SE¼ sec. 15, T. 3 S., R. 1 W.	Huntsville Wholesale Nurseries	Tyler Darwin	D	197	6	38	C	Top of casing		—93	11- 9-48			Irr	
20	NW¼ NE¼ sec. 17, T. 3 S., R. 1 W.	J. H. Burgess	J. D. Burgess	Du	11	24	11	S	Top of casing	3	—4.35	6-28-49	HP		S	
21	NW¼ NE¼ sec. 17, T. 3 S., R. 1 W.	J. H. Burgess	....	D	55.4	6		T	Top of casing	1.7	—34.2	6-28-49	W	62.5	D, S	
22	SW¼ SE¼ sec. 12, T. 3 S., R. 2 W.	K. M. & H. B. Bryant	....	D	96	6		T	Top of casing		—70	6-28-49	EP	62.3	D	
23	SW¼ SE¼ sec. 1, T. 3 S., R. 2 W.	K. M. Bryant	.....	D	69.1	6		T	Top of casing	6	—40.6	6-28-49	W	62.4	D, S	
24	SE¼ SW¼ sec. 11, T. 3 S., R. 2 W.	Mayes Place	....	D	75	6		T	Top of casing			6-28-49	EP		D, S	
25	NW¼ NW¼ sec. 23, T. 3 S., R. 2 W.	R. E. Vaughn	Jim James	B	104	6	104	T	Top of casing		—90	6-28-49	EP		D, S	

Table 5.—Well data from the Huntsville area of Alabama—Continued

Well No.	Location	Owner or Name	Driller	Type of well	Depth of well (ft.)	Diameter of casing (in.)	Depth of casing (ft.)	Principal water-bearing formation	Water level			Date of measurement	Method of lift	Temperature °F.	Use	Remarks
									Description of Measuring Point (MP)	MP above land surface (feet)	Water level below (—) MP (feet)					
26	NW¼ NW¼ sec. 23, T. 3 S., R. 2 W.	R. E. Vaughn	.....	Du	45	36	45	S	Top of casing		—15	6-28-49	EP		D, S	
27	NW¼ NW¼ sec. 26, T. 3 S., R. 2 W.	R. E. Holder	.....	D	127	8	128	T	Top of casing		—98	1940	EP		D, S	Yields 3½ g.p.m.
28	NE¼ SE¼ sec. 23, T. 3 S., R. 2 W.	R. E. Vaughn, Jr.	.....	Du	46.8			S	Top of casing	2.5	—32.5	6-28-49	EP	63.5	D, S	
29	NE¼ NE¼ sec. 19, T. 3 S., R. 1 W.	J. H. Johnstone	Hawley Dodson	D	82	6	35	T	Top ground		—73	6-28-49	EP	63.5	D, S	Yield 5 g.p.m.
30	NW¼ NW¼ sec. 30, T. 3 S., R. 1 W.	W. A. Brockway	Frank Jones	D	85	6	70	T	Top ground		—70	6-28-49	EP		D, S	
31	SE¼ SW¼ sec. 30, T. 3 S., R. 1 W.	Virginia Mitchell	.....	Du	46.45	36		S	Top of casing	3.0	—29.76	6-28-49			D, S	
32	NE¼ NE¼ sec. 30, T. 3 S., R. 1 W.	H. L. Wright	Hawley Dodson	D	148	8		T	Top of casing		—135	6-28-49	EP			
33	SW¼ SE¼ sec. 20, T. 3 S., R. 1 W.	Oakwood College	Hawley Dodson	D	175	8		T	Top of casing	2.0	—160	6 -28-49	EP		Sch	
34	NW¼ NE¼ sec. 29, T. 3 S., R. 1 W.	Oakwood College	Hawley Dodson	D	130	8		T	Top of casing		—60	6-28-49	EP	61.5	Sch	
35	SE¼ SW¼ sec. 25, T. 3 S., R. 1 W.	Lincoln Mills	M. W. Willbanks	D	107-111	20′ x 5⅝″		T	Top of casing		—40	3-16-45	EP		Ind	Eight drilled wells in bottom of dug well. Anal.
36	SW¼ SE¼ sec. 25, T. 3 S., R. 1 W.	Dallas Mfg. Co.	Hutchins	D	135	5-⅝		T	Top of casing		—20	11- 9-48	EP	64	D, S	

37	SW¼ SE¼ sec. 25, T. 3 S., R. 1 W.	Dallas Mfg. Co.	Hutchins	D	120	8		T	Top of casing		—20	11- 9-48	EP	64	D, Ind	
38	SW¼ SE¼ sec. 25, T. 3 S., R. 1 W.	Dallas Mfg. Co.	Hutchins	D	125	6		T	Top of casing		—20	11- 9-48	EP	64	D, Ind	
39	SW¼ SE¼ sec. 25, T. 3 S., R. 1 W.	Dallas Mfg. Co.	Hutchins	D	99	7		T	Top of casing		—20	11- 9-48	EP	64	D, Ind	
40	SW¼ SE¼ sec. 25, T. 3 S., R. 1 W.	Dallas Mfg. Co.	Hutchins	D	110	6		T	Top of casing		—20	11- 9-48	EP	64	D, Ind	
41	SW¼ SE¼ sec. 25, T. 3 S., R. 1 W.	Dallas Mfg. Co.	Hutchins	D	171	6½		T	Top of casing		—20	11- 9-48	EP	64	D, Ind	
42	SW¼ SE¼ sec. 25, T. 3 S., R. 1 W.	Dallas Mfg. Co.	Willbanks	D	109	5⅝		T	Top of casing		—20	11- 9-48	EP	64	D, Ind	
43	SW¼ SE¼ sec. 25, T. 3 S., R. 1 W.	Dallas Mfg. Co.	Willbanks	D	108	7		T	Top of casing		—20	11- 9-48	EP	64	D, Ind	
44	SW¼ SE¼ sec. 25, T. 3 S., R. 1 W.	Dallas Mfg. Co.	P. J. Mohoney	D	112	6	35	T	Top of casing		—20	11- 9-48	EP	64	D, Ind	
45	SW¼ SE¼ sec. 25, T. 3 S., R. 1 W.	Dallas Mfg. Co.	P. J. Mohoney	D	116	8		T	Top of casing		—20	11- 9-48	EP	64	D, Ind	
46	NW¼ SW¼ sec. 34, T. 3 S., R. 1 E.	Ernest Troup	Hawley Dodson	D	84	8¼	16	P	Land surface		—12	6-30-49	EP		D	
47	SW¼ SE¼ sec. 28, T. 3 S., R. 1 E.	Geo. Massie		Du	26.9	36		S	Top wood housing	2.5	—6.7	6-30-49	EP		D	
48	SW¼ SE¼ sec. 28, T. 3 S., R. 1 E.	Geo. Massie		D	83	6		P	Top of casing	.6	—43	6-30-49	EP		DS	
49	NW¼ NW¼ sec. 24, T. 3 S., R. 1 E.	Johnny Martin	Woodward	D	93	6		T	Top of casing		—35	6-29-49	EP		D, S	
50	NE¼ NW¼ sec. 24, T. 3 S., R. 1 E.	Ryland Gin Co.		D	75	6		T	Top of casing		—40	6-29-49	EP	63	Ind	
51	SW¼ NW¼ sec. 24, T. 3 S., R. 1 E.	Sam Loveday	Jones	D	87.5	6	26	T	Top of casing		—56.5	6-29-49	W	62	D, S	
52	NE¼ SW¼ sec. 24, T. 3 S., R. 1 E.	Carl Morry		D	75	6		T	Top of casing	1.7	—49.8	6-29-49	W	63	D	

Table 5.—Well data from the Huntsville area of Alabama—Continued

Well No.	Location	Owner or Name	Driller	Type of well	Depth of well (ft.)	Diameter of casing (in.)	Depth of casing (ft.)	Principal water-bearing formation	Water level: Description of Measuring Point (MP)	Water level: MP above land surface (feet)	Water level: Water level below (—) MP (feet)	Water level: Date of measurement	Method of lift	Temperature °F.	Use	Remarks
53	NE¼ SE¼ sec. 5, T. 4 S., R. 1 E.	W. H. Burritt	Frank Jones	D	65.1	6		P	Top of casing		—38	6-30-49	W		D, S	
54	SW¼ SW¼ sec. 10, T. 4 S., R. 1 E.	G. H. Harden	Hawley Dodson	D	149	6		T	Top of casing		—135	6-30-49	EP		D, Ind	
55	SE¼ SW¼ sec. 17, T. 4 S., R. 1 E.	G. W. Jones & Sons	G. W. Jones & Sons	Du	27	36	21	T	Top of casing		—11	11-12-48	EP	63	D, S	Yield 35 g.p.m. Analysis.
56	NW¼ SE¼ sec. 1, T. 4 S., R. 1 W.	Roper Floral Co.	Dodson-Jones	D	525	6	525	C	Top of casing		—23.1	12- 2-48				Not used.
57	NW¼ SE¼ sec. 1, T. 4 S., R. 1 W.	Roper Floral Co.	Jennings	Du	36	60-48		S	Top curbing		—30	11-10-48	EP		Irr	Yield 4 g.p.m. Analysis.
58	NW¼ SE¼ sec. 1, T. 4 S., R. 1 W.	Roper Floral Co.	.....	Du	31	60		S	Top curbing			11-10-48	EP		Irr	Yield 12½ g.p.m.
59	NW¼ SE¼ sec. 1, T. 4 S., R. 1 W.	Dr. Whittaker Clinic	Hawley Dodson	D	200	8¼		C	Top of casing		—26.8	12- 2-48	EP	61	Ind	Yield 27 g.p.m.
60	NW¼ SE¼ sec. 1, T. 4 S., R. 1 W.	Dr. Whittaker Clinic	Hawley Dodson	D	124	8¼		T	Top of casing		—26	1-15-49	EP	61	Ind	Yield 36 g.p.m.
61	SW¼ SE¼ sec. 2, T. 3 S., R. 1 W.	General Shoe Corp.	.....	D	85	8		T	Top of casing		—12.4	6- 7-48	EP	62		Not used; capacity 500 g.p.m. Analysis.
62	SW¼ SE¼ sec. 2, T. 3 S., R. 1 W.	General Shoe Corp.	.....	D	85	8		T	Top of casing		—12.4	6- 7-48	EP	62		Yield 475 g.p.m. Not used.
63	SW¼ SE¼ sec. 2, T. 4 S., R. 1 W.	General Shoe Corp.	.....	B	85	8		T	Top of casing			3- 8-45	EP		Ind	Yield 475 g.p.m.

64	SW¼ NW¼ sec. 3, T. 4 S., R. 1 W.	Martin Stove Co.	Hawley Dodson	D	60	4	60	T	Top of casing			11-10-48	EP		Ind	
65	SE¼ SW¼ sec. 3, T. 4 S., R. 1 W.	Holland Warehouse		Du	22	216		S	Top of casing		—5.5	11-10-48				Not used.
66	NW¼ NW¼ sec. 4, T. 4 S., R. 1 W.	W. L. Sanderson	Joe Cambron	D	62	8	52	T	Top of casing		—20	6-1947	EP	61	D, S	Yield 17 g.p.m. Analysis.
67	SE¼ SW¼ sec. 6, T. 4 S., R. 1 W.	L. C. McDonald		Du	47	36		S	Top of casing		—5	6-29-49	EP	63	D, S	
68	NE¼ NW¼ sec. 7, T. 4 S., R. 1 W.	L. C. McDonald	J. E. Cambron	D	57.8	6		T	Top of casing	1.7	—40.6	6-29-49	W			Not used.
69	SE¼ SW¼ sec. 1, T. 4 S., R. 2 W.	John L. Robinson		D		6	27	C	Top of casing			6-29-49				Well plugged.
70	NW¼ NW¼ sec. 12, T. 4 S., R. 2 W.	R. E. Camper	Hawley Dodson	D	85	6	40	T	Top of casing		—40	6- 2-49	EP	63	D, S	Analysis.
71	SW¼ SW¼ sec. 1, T. 4 S., R. 2 W.	Mrs. John L. Robinson		D	180	6		T								Test well. Failed.
72	NW¼ NE¼ sec. 2, T. 4 S., R. 2 W.	Fred Jones	John Patton	Du	34	36		S	Top curbing	2	—5.9	6- 2-49	W	63	D, S	
73	SE¼ NW¼ sec. 31, T. 4 S., R. 1 E.	J. E. Hays		D	120	6		T	Top of casing		—40	6-29-49	EP	63	D, S	
74	SE¼ NW¼ sec. 30, T. 4 S., R. 1 E.	A. Fleming & Sons	Jimmy James	D	67	6	45	T	Top of casing		—30	11- 2-48	EP	60	D, S, Ind	Yield 5 g.p.m. Analysis.
75	SW¼ SW¼ sec. 20, T. 4 S., R. 1 E.	Archie Hill		D	63	6		T	Top of casing	2	—27.5	6-29-49	W	63	D, S	
76	SE¼ SE¼ sec. 20, T. 4 S., R. 1 E.	R. E. Fanning		Du	25.9	36		S	Top wood housing	2.9	—17.6	6-29-49	W	63	D, S	
77	SE¼ SE¼ sec. 20, T. 4 S., R. 1 E.	R. E. Fanning		D	81.5	6	33	C	Top of casing	1.5	—32.5	6-29-49	W	63	D, S	
78	NW¼ SE¼ sec. 32, T. 4 S., R. 1 E.	J. E. Weatherly	Mayo	D	87	8	20	T	Top of casing		—20	6-29-49	EP	63	D, S	Yield 7 g.p.m.
79	NE¼ NE¼ sec. 22, T. 4 S., R. 1 E.	Robert F. Cowly		Du	31	36		T	Top of casing		—15	6-30-49	EP	63	D, S	

Table 5.—Well data from the Huntsville area of Alabama—Continued

Well No.	Location	Owner or Name	Driller	Type of well	Depth of well (ft.)	Diameter of casing (in.)	Depth of casing (ft.)	Principal water-bearing formation	Water level			Date of measurement	Method of lift	Temperature °F.	Use	Remarks
									Description of Measuring Point (MP)	MP above land surface (feet)	Water level below (—) MP (feet)					
80	SE¼ NE¼ sec. 26, T. 4 S., R. 1 E.	James Long		D	38	6	36	T	Top of casing			11-11-48	EP	63	D, S	Water level could not be measured.
81	SW¼ NW¼ sec. 25, T. 4 S., R. 1 E.	A. E. Sublett	Adams	D	28	6	26	T	Top of casing		—8	11-11-48	EP	63	D, Ind	Yield 125 g.p.m.
82	NW¼ NW¼ sec. 2, T. 5 S., R. 1 E.	Lawrence O. Smith		D	40	36		T	Top of casing		—20	6-30-49	W	63	D, S	
83	NE¼ NW¼ sec. 11, T. 5 S., R. 1 E.	I. Shipman Co.	Hawley Dodson	D	100	6	60	T	Top of casing		—20	6-30-49	EP	63	D, S	
84	NW¼ SW¼ sec. 4, T. 5 S., R. 1 E.	F. A. Miller		Dr	25.04	6		T	Top of casing	1.5	—12.1	6-29-49	HP	62	D, S	
85	SW¼ SE¼ sec. 8, T. 5 S., R. 1 E.	James Adkins		Du	22.1	36		S	Top wood housing	2.3	—14.1	6-29-49	W		S	
86	SW¼ SE¼ sec. 8, T. 5 S., R. 1 E.	James W. Adkins	Butler Bros.	D	50.5	6	20	T	Top casing		—2	6-29-49	W	63		
87	NE¼ NW¼ sec. 7, T. 5 S., R. 1 E.	C. N. Buchanan		Du	40	72		T	Top rock curbing		—30	11-12-48	EP		D, S	Yield 42 g.p.m.
88	NE¼ SW¼ sec. 18, T. 5 S., R. 1 E.	John Anderson		D	90	6		T	Top casing		—40	6-28-49	EP	63	D, S	
89	SW¼ NE¼ sec. 13, T. 5 S., R. 1 W.	H. J. Bell	Frank	D	98	6		T	Top casing		—40	6-29-49	EP	63	D, S	
90	NE¼ NE¼ sec. 19, T. 5 S., R. 1 E.	C. L. Cooper	Lewis Bolding	D	155	8-6	16	T	Top casing		—38	11-12-48	EP	63	D, Ind	Analysis.

91	SE¼ NE¼ sec. 20, T. 5 S., R. 1 E.	Phillips Brick & Tile Co.	.....	D	130	8	40	T	Top casing		—10	11-11-48	EP		Ind	
92	SE¼ NE¼ sec. 20, T. 5 S., R. 1 E.	Phillips Brick & Tile Co.	.....	D	40	8	40	T	Top casing		—15	11-11-48	EP		D	
93	NW¼ NW¼ sec. 20, T. 5 S., R. 1 E.	Farley Colored School	Jasper Hill	D	202	6¼	16	C	Top casing		—100	6-30-49	EP		D, Sch	

Table 6.—Spring Data from the Huntsville Area of Alabama

Numbers correspond with those on Plate 1.
Water-bearing formations: M, Mississippian limestone; T, Tuscumbia limestone; B, Bangor limestone; G, Gasper formation.
Use of water: D, domestic; Ind, Industrial; Irr, irrigational; PS, public supply; FP, fire protection; R, recreational.
Structure is horizontal.

Spring Number	Location	Owner or Tenant of Property	Name	Principal water-bearing formation	Use of water	Yield (g.p.m.)	Date of Measurement	Temperature °F.	Remarks
1	NE¼ SW¼ sec. 1, T. 3 S., R. 1 E.	Alabama Hide & Tallow Co.	Boiling	M	Ind	See remarks	—	61	Dr. Jones, State Geologist, estimates flow to approximate that of Huntsville Spring.
2	NE¼ SE¼ sec. 14, T. 3 S., R. 1 E.	D. C. Acuff	Acuff	T	Ind	1,500	7-10-49	60	Water cress farm. Analysis.
3	NE¼ SW¼ sec. 28, T. 3 S., R. 1 E.	Unknown	Cold	B	D	15	11-13-48	54	Analysis.
4	Cen., SW¼ sec. 36, T. 3 S., R. 1 W.	City of Huntsville	Huntsville	T	PS	See text	—	60.8	Analysis.
5	SE¼ SW¼ sec. 8, T. 3 S., R. 1 E.	Chase Nursery	Chase	T	Irr	5	7-10-49	62	Yields 25 gallons a minute in wet weather.
6	SW¼ SW¼ sec. 7, T. 3 S., R. 1 E.	Alabama A & M College	College	G	R	2	11-12-48	63	Piped to fish pond.
7	NE¼ NE¼ sec. 17, T. 3 S., R. 1 W.	J. H. Burgess	Burgess	T	D	10+	6-28-49	63.5	Seasonal variation. Supplies three homes.
8	NW¼ NW¼ sec. 2, T. 3 S., R. 2 W.	D. E. Kelly	Indian	T	Ind	3,500	7-12-29	63	Water cress farm.
9	SE¼ SE¼ sec. 3, T. 4 S., R. 1 W.	West Huntsville Warehouse	West Huntsville	T	FP	300	7-16-49	61	Flows into large well.
10	SE¼ NW¼ sec. 11, T. 4 S., R. 1 W.	Huntsville Mfg. Co.	Brahan	T	Ind +PS	See remarks[1]	1-14-49	62	Flows 6,200 g.p.m. Analysis.
11	SW¼ NW¼ sec. 4, T. 4 S., R. 1 E.	Monte Sano State Park	Park	B	D—Ind	——	11- 9-48	60	Flow could not be measured.
12	SW¼ NW¼ sec. 25, T. 4 S., R. 1 W.	Byrd Springs Rod & Gun Club	Byrd	T	R	3,725[1]	1-14-49	61.5	Only partial flow could be measured. Analysis.

[1]Measurement made by Surface Water Branch, U. S. Geological Survey.

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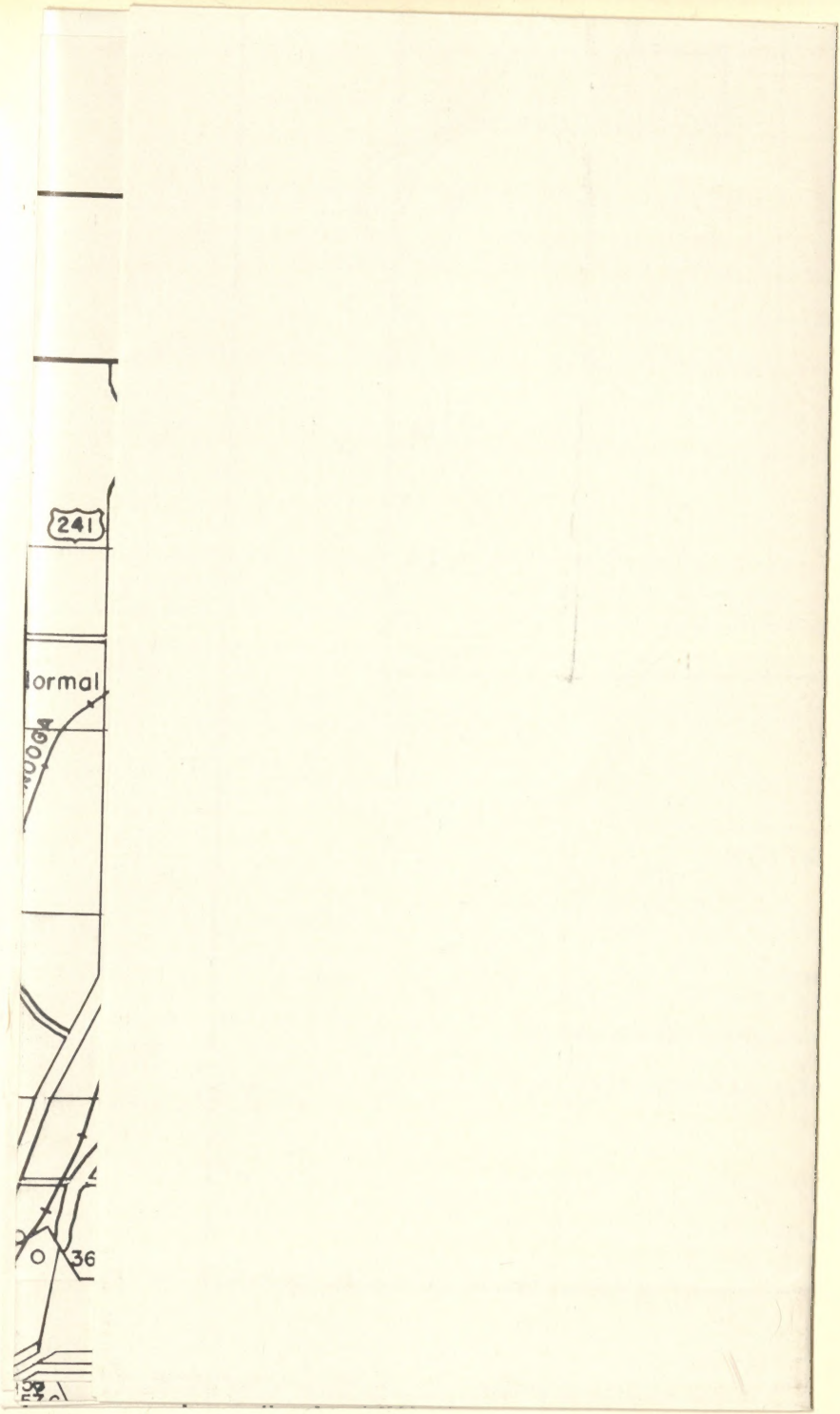
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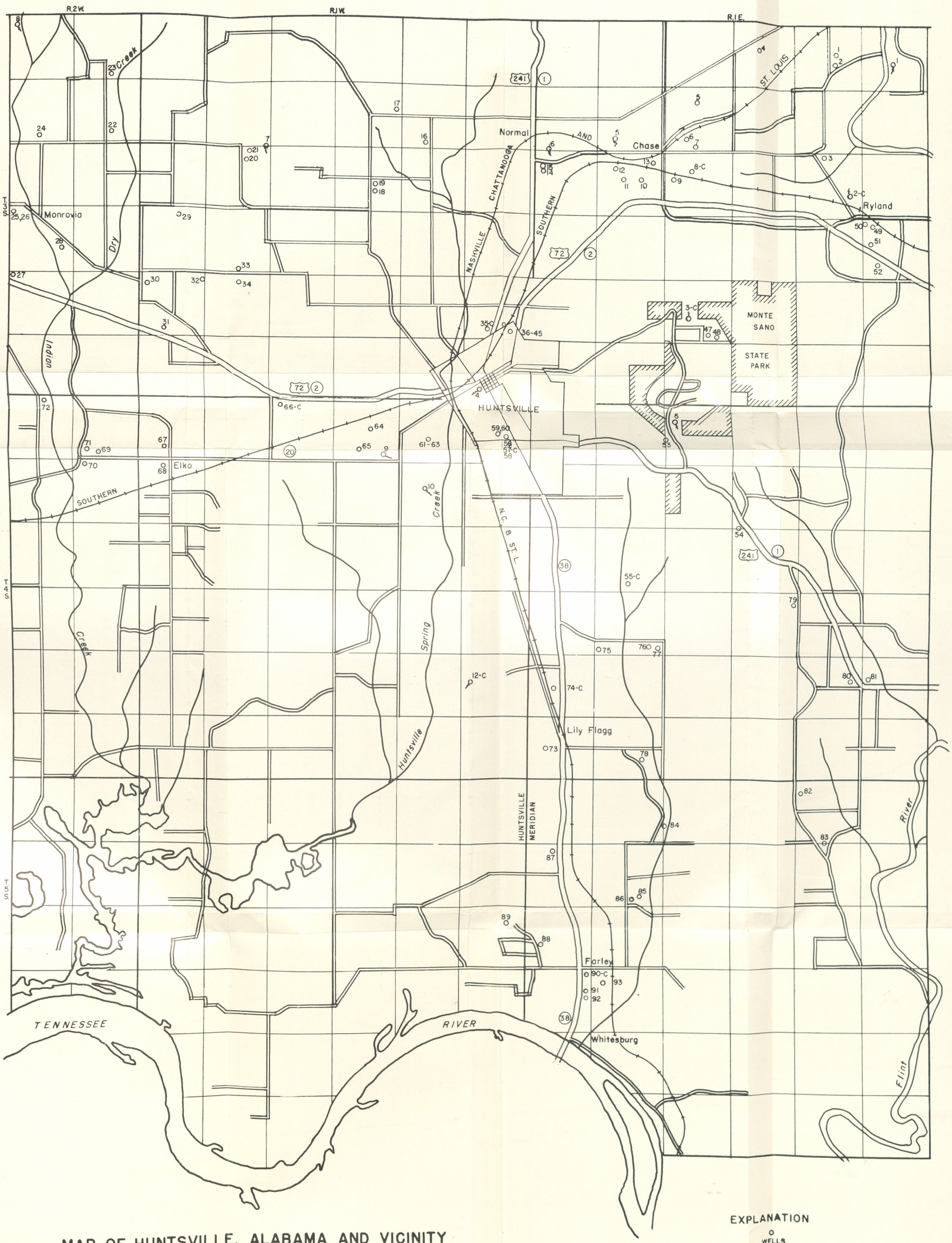

MAP OF HUNTSVILLE, ALABAMA AND VICINITY

Showing location of ground-water supplies for which records are tabulated.

SCALE IN MILES

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EXPLANATION

WELLS

SPRINGS

8-C
WELL WITH CHEMICAL ANALYSIS AVAILABLE.

Q2-C
SPRING WITH CHEMICAL ANALYSIS AVAILABLE.